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A Systems Perspective

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Springer

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ISBN 978-3-032-11448-8 ISBN 978-3-032-11449-5 (eBook)
https://doi.org/10.1007/978-3-032-11449-5

This work was supported by Harvard Graduate School of Education.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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Chapter 1
Education and Artificial Intelligence: A Systems Approach

1.1 Purpose of the Book

This book examines the ways in which artificial intelligence can transform education systems. By artificial intelligence we mean "the simulation of human intelligence by machines, especially computer systems…[with] the capability to behave like humans in tasks such as communicating, memorizing, reasoning, and learning" (Martin et al., 2024). By education systems we refer to the set of institutions explicitly designed and funded to help learners develop knowledge and skills, with particular attention to those that provide opportunities to learn to the majority of the population, which is to say those who focus on compulsory education. In most countries those include education at the pre-school, elementary and secondary level, or what some refer to as basic education. There are other institutions designed to help learners develop knowledge and skills, such as universities, institutions for workforce development or lifelong learning. Because they focus on subsets of the population, and because there is greater heterogeneity among them, they will not be the focus of this book. Instead we will focus on the education institutions which will impact most of humanity over time.

While education systems serve multiple purposes and constituencies, a core goal is to provide learners with opportunities to learn. Those involve the intended goals of the curriculum—what should be learned—and the achieved curriculum goals—what is actually learned. Optimizing education systems on that core goal consists, therefore, of improving the opportunity of students to learn what is intended—improving the effectiveness of the system—and improving the opportunity of students to learn a curriculum that helps them advance their circumstances—improving the relevance of the system. A system needs to, at a minimum, be effective in teaching 'the basics', but it should also strive to be relevant to a changing world of rising skill demands. In a world in which those rising demands encompass skills to work in an AI-shaped world, a subset of relevant skills includes 'AI literacy'. AI literacy is a multi-dimensional competency including (a) the knowledge of how AI works

F. Reimers et al., *Artificial Intelligence and Education in the Global South*,
https://doi.org/10.1007/978-3-032-11449-5_1

and how to develop it, (b) the competency to engage with AI as a form of 'co-intelligence' (Mollick, 2024), using it effectively, and (c) the capacity to discern the impact of AI on humans and societies and to engage with the ethical dilemmas that such impact creates. It is with respect to these three goals: developing AI literacy, improving the effectiveness of schools, and improving the relevance of schools, that we will examine the potential of AI in education.

Our starting point in approaching this subject is one of open-minded agnosticism. While we recognize that AI is a most intriguing technology that has proven capable of remarkable feats, we don't necessarily assume that the power of AI can transform education for the better. In part our agnosticism is predicated on the fact that there are too many examples of technology applications in education that failed to fulfill their promise. A recent report on the use of technology in education around the world concludes that "except in the most technologically advanced countries, computers and devices are not used in classrooms on a large scale. Technology use is not universal and will not become so any time soon. Moreover, evidence is mixed on its impact" (UNESCO, 2023). Our open mindedness is predicated on the hope that we can learn from past successes as well as failures, and from comparative experience. The goal of this book is to animate reflexion and dialogues that can help bring that hope into fruition.

Here we make a distinction between educational improvement and educational transformation. AI can improve education if it can be applied to support teaching and learning in some way. In order to transform education, however, AI would need to show that it can solve some of the most important education problems, not just that there are possible applications of AI to education. Those important problems center squarely on the three domains of educational opportunity just mentioned: AI literacy, education effectiveness, and education relevance (which includes AI literacy but extends beyond it). Transformation also requires that AI solutions can be implemented at scale, not just in a few schools. The distinction between improvement and transformation is important because just about any innovation, including those based on technology, can produce some improvement if it is well thought out. But improvement on problems which are not critical, or in ways which can't be scaled, or sustained, is of limited use to transform a system. For example, a recent scoping exercise of the deployment of AI education solutions in Latin America concludes that there has been very limited adoption of AI in education systems in the region (Rivas, 2025). Relatedly, a recent study of the extent to which smart classrooms could address teachers' perceived needs identifies an important research gap, in that most research focuses on technical elements of the technological innovation rather than on the interaction of humans with the innovation, with very scant information on the extent to which smart classrooms in fact address the pedagogical needs of teachers (Ferreira et al., 2025). This book aims at helping the reader discern whether AI can in fact solve important problems in education, perhaps animate developers to create AI-enabled applications to solve those problems, stimulate all to think about the ethical implications of using AI to address crucial education problems, as well as map a research agenda that can contribute evidence to help answer these questions.

To serve our goals, we will follow a similar structure in each of the chapters that follow. In discussing what role AI could play in education systems we will begin with the most salient education challenges, to then discuss if and how AI could address them, we will then review the existing evidence as to whether AI developments have shown themselves capable of addressing those challenges, to then raise ethical questions about the use of AI in that domain and then formulate some of the questions that future research should try to answer to generate evidence that can help advance the field. The evidence we examine is of two kinds: evidence that illustrates applications of AI, and evidence that evaluates some of those applications. We draw on published reports in academic journals and from international organizations, such as the OECD, the Organization of Iberoamerican States, or UNESCO to identify uses of AI. We relied on academic databases such as Jstor, ProQuest, EBSCOhost, Scopus and Google Scholar to identify relevant articles to review. Our goal in our search for AI applications was not to be comprehensive and exhaustive in mapping all existing uses, but to cover all types of applications, illustrating each type with some examples. It is possible that the sources of evidence we have examined are biased in at least two ways. The first source of bias results from the very dynamic nature of the object we are studying and the relatively slower pace of documenting and evaluating applications. It takes a year or two, or more, to evaluate an educational intervention, but a year is a very long time in the field of AI, as many things can be developed during that period. As a result, the information available, particularly evaluative information, pertains to applications of AI that are behind what current developments in the field may be. This is the reason we have also relied on documentations of AI applications, even if they haven't yet been evaluated, as typically documentation is available sooner than an evaluation is even possible. These shortcomings of the knowledge base on which we are relying should be kept in mind in reading our conclusions in each chapter and in the book. When we say that we haven't found applications of AI to address particular education challenges this should be read as meaning quite literally that we did not find the application, not that those applications were not available—they may indeed exist but perhaps have not yet been documented or evaluated. The second shortcoming stems from the nature of our sources, which tend to focus on how AI is deployed in schools and education systems. Clearly schools are only one of the settings in which people learn, much learning is possible, and indeed takes place, as people learn independently, in their own time, or in informal education spaces. But those forms of learning are not as frequently evaluated as those that pertain to uses in schools. The fact that our sources of knowledge of how AI has been deployed to support learning are tied to learning in schools may induce a certain conservative bias in our findings. Schools are more likely to focus on the delivery of a set curriculum than they are on allowing students to follow a self-directed curriculum. It is very possible that learners are using AI applications to gain skills and knowledge of their own choosing, but such uses are just not as well documented or studied. Given this bias in our sources we may miss important uses of AI and conclude that much of it relates to transmitting a standardized curriculum, rather than empowering students to create their own curriculum, and this conclusion should again be interpreted

conscious of the limitations of the knowledge base on which we rely. Another word on the knowledge base we examined, even though our focus is on the Global South, where appropriate we have also included examples from other regions to examine what kind of uses of AI are possible.

This introductory chapter lays the foundation for understanding the transformative potential of AI in education, underscoring the need for systemic, policy-driven, and collaborative approaches that both harness the benefits of AI and address its attendant risks. In subsequent chapters, we will further explore how these principles can be applied and adapted to diverse educational contexts, with particular attention to the unique challenges and opportunities faced in the Global South.

1.2 Why This Book on Education and Artificial Intelligence?

Artificial Intelligence is disrupting the world of work, as computer systems take on tasks previously performed by humans. These changes have profound implications for education. Some of the potential applications of AI to education hold great promise, offering the potential to improve learning outcomes, educational access, and workforce preparation. They may in fact bring about veritable transformations, not just innovations or disruptions. At the same time, the disruptions brought by AI in education can have significant costs for particular groups—for example, augmenting inequalities among students with access to different levels of academic preparation, or exacerbating inequalities in access to digital skills, thus limiting opportunities to participate in the emerging world of "co-intelligence," where humans work together with AI-enabled platforms. There is reason to be concerned about the possible augmentation in educational, and consequently social and economic, inequality resulting from differential access to this technology, as this was very much one of the effects of the efforts to sustain education through remote learning during the recent COVID-19 pandemic (Reimers, 2022). If the use of AI in education disproportionately advantages students who are already advantaged because of the higher quality of education they receive, or because their superior access to digital resources and other supports, it will compound the inequalities in the world of work resulting from better rewards for those working in areas that can leverage co-intelligence with AI. At present AI seems to be having the greatest disruptive effect on knowledge-based jobs -occupations that primarily rely on expertise, and intellectual capabilities rather than manual skill, and not so much on jobs that depend on physical labor. However, this may change as knowledge-based jobs are redesigned to better leverage the power of AI. A recent report on global trends impacting education explains that the adoption of AI in the workforce requires different skill sets, and that AI is expanding the capacity of robots and systems to work collaboratively with humans, essentially reshaping labor markets (OECD, 2025).

Other causes for concern from uses of AI in education include the possibility that it may 'de-skill' humans, making us lose important cognitive skills as we depend more on assistance of AI to perform them, or that it may cause us to place undue trust and insufficient attention to the limitations of AI as it performs certain tasks.

This book examines what kinds of educational transformations can be brought about by using AI, and what strategies can mitigate its potential costs and adverse effects. There are at least three reasons educational institutions should think about Artificial Intelligence and they guide our inquiry in this book. The first is that the transformation of the world of work by AI creates the need for AI literacy. The second is that the transformation in the workplace resulting from AI will change the relative value of human skills and knowledge. Beyond the skills involved in using AI, these include skills for human collaboration and interaction, but also ethical and moral reasoning skills, such as thinking about the ethical implications of incorporating AI to various domains. A world transformed by AI leads to the need to cultivate definingly human skills. The third reason educational institutions should be concerned with AI, is that AI-enabled applications can transform a variety of organizational processes, and this is also the case in education. This leads to the opportunity to deploy AI to improve the effectiveness of education, as well as its relevance. Can AI help us reimagine education, becoming more effective in reaching well established goals, as well as more relevant in achieving goals which were previously out of reach because of the existing modalities of education?

To address these questions, which will be the focus of this book, we will synthesize various strands of scholarship and professional literature. We will draw on what is known so far about the applications of AI in education, though this literature is decidedly still limited while growing rapidly, as the applications of AI increase exponentially. We will draw also on what is known about the functioning of education systems, and about existing options to improve their effectiveness and relevance, and will extrapolate from that literature the likely implications as we envision a fuller integration of AI in education. It is in the examination of what is known about the potential and actual uses of AI, in light of what is known about what problems matter in education and how education systems improve at scale that lies the unique value of this book. There are already a number of reviews of research literature on the applications of AI to education, and we draw on them in this book, but for the most part these reviews are 'self-contained', that is they don't examine whether the results of using AI relate to the most vexing education challenges, or how the use of AI would integrate with the functioning of education systems at scale.

The book is addressed to those who play a role supporting the functioning of education systems, including teachers, school administrators and policy makers and planners, as well as those working in organizations that partner with public education systems, such as technology companies or organizations that support schools developing curriculum, teachers, assessment efforts or in other improvement efforts. While the book may be of interest to the general public, or to students or parents, they are not the primary audience that we have had in mind in writing it.

1.3 Why Do We Focus on the Global South?

While there are implications of the development of artificial intelligence for education everywhere, the implications are likely different depending on a number of specific conditions in every context. Four among them are: the number of learners affected, the functioning and challenges facing education systems, the level of resources available for education and the degree of impact and integration of AI in the communities where schools are embedded. Conditions are likely very different in countries with a relatively low proportion of students, relative to the total population, than in countries with a larger share of the population of school-going age, or in relatively small education systems vs. large education systems. Similarly, in countries with high functioning education systems the challenges and opportunities will be different than in countries where systems are fragile and facing multiple challenges. The level of financial resources per student is also likely to impact the incorporation of AI to education, as is the integration of AI and technology more generally into the economies and functioning of the communities in which schools are embedded.

While there isn't yet a classification of countries based on a taxonomy that incorporates the four dimensions just described, a proxy, admittedly imperfect, for them is to group countries in terms of level of income per capita. An older classification along these lines, no longer widely used, distinguished between developed, or early industrialized and developing countries. International development agencies such as the World Bank, group countries in four tiers based on income per capita: low income, lower middle income, upper middle income and high income. A more recent classification originates in a 1980 report authored by former German Chancellor Willy Brandt which divided the world into a wealthy 'North' and a poorer 'South'. The Global South includes most countries in Africa, Latin America, the Caribbean, Asia, and Oceania (excluding Australia and New Zealand). The Global South includes also highly-populated countries such as China, India, Indonesia, Pakistan, Bangladesh, Brazil, Nigeria, and Mexico. About 85% of the world's population lives in the Global South. Given the higher birth rates and the greater proportion of youth in the Global South, 90% of the world's population under the age of 18 lives there (United Nations, 2022).

In this book we will use the term Global South because it is an effective shorthand to refer to the countries where the majority of the world's population lives, which are also countries with lower levels of resources per capita and lower levels of resources per student.

This book is therefore focused principally on the Global South because it is where most of the population of school age is, meaning that transformations in education will have the greatest impact there. These countries also face the greater challenge of having to educate a greater share of the population, which stretches the financial and institutional resources available to education systems. Given these challenges, the opportunity cost of introducing 'distractions' is greater there. It is not enough for applications of AI in education to produce some improvement, if it

does not also lead to transforming systems in their capacity to address the main challenges they face. To simplify, if in a system in which the vast majority of children are unable to learn to read and write, an AI education curriculum which helps a very small proportion of children in this system become AI literate, and that does so with resources which could have been deployed to help all children learn to read and write, this curriculum is not just augmenting inequality, but a distraction from addressing the elephant in the room, which is the poor functioning of the education system in allowing all children to gain foundational skills.

We should recognize, however, that the Global South is far from monolithic not only in the differences which exist among countries, but in the differences that exist between regions within countries; effective AI integration must therefore be attuned to local needs and priorities, languages, cultures, resources, and pedagogies. Technology that works well in high-resource settings may need adaptation or reimagination for contexts with intermittent connectivity, large class sizes, or limited teacher professional development opportunities. For instance, AI can be used to support education even in settings in which students have limited access to connectivity and devices, for example supporting teachers in grading student written work on notebooks. Thinking systemically about education institutions is a path to helping us understand those context dependencies in examining the transformative potential of Artificial Intelligence.

1.4 Thinking Systemically

An education system encompasses the entire organizational infrastructure through which a nation, or subnational entity, delivers education for the population. Such infrastructure comprises policies, institutions, structures and processes intentionally designed and sustained for the purpose of passing on to the next generation the knowledge, skills and values that a society considers important. They include schools and universities, curricula, teachers, instructional resources, buildings, equipment, and assessment. Policies and regulations norm the functioning of those institutions, and those are guided by education goals and philosophy, and supported by funding and education resources. It is helpful to think of a system not as a static platform, but as an organic and dynamic entity, where direction and functioning are the result of the interactions between components, rather than the mere additive results of them. The study of complex systems, the subject of complexity science (Mitchell, 2009), has identified regularities and laws that are proper to their functioning, such as the fact that small causes can have big effects, and that relationships between cause and effect are non-linear and sensitive to initial conditions. A tiny input or change can lead to disproportionately large impacts due to feedback loops and nonlinear relationships (Mitchell, 2009). Or the principle of emergence, which refers to the fact that complex, organized behavior can arise from simple local interactions among components, without central control (Holland, 1998). Another principle of complex systems is that they can adapt and reorganize spontaneously in

response to changes in their environment (Waldrop, 1992). System dynamics are governed by positive and negative feedback loops created by interactions in the system which can stabilize or destabilize the system (Meadows, 2008). No single part of the system has complete control; instead, control and information are distributed (Bar-Yam, 1997).

The concept of 'system' alludes to the fact that these various elements work in concert with one another, they interact, they are not a collection of independent components, but all part of a whole whose functioning is the result not just of the sum of each of their individual effects but of their interactions. For example, curriculum, teachers, and evaluation systems are not three independent components of an education system, but interdependent elements that need coherent alignment in order to operate in service of learning. Curriculum, the set of educational goals that guide education, and the scope and sequence that translate those goals into a learning progression, needs to work in tandem with teachers, taking into account and leveraging their capacity and ideas. A curriculum is not self-executing, but becomes alive when teachers use that curriculum to guide the interactions they have with their students and with instructional resources. If a curriculum makes cognitive demands that exceed the capacities of teachers, professional development would be necessary so that teachers can make the curriculum come alive in the classroom. Relatedly, no curriculum should be too far off from what teachers understand and can do, and even want to do, and that is the reason piloting a curriculum, and finding other ways to give teachers voice in designing curriculum, is sensible in order to achieve alignment between the scope and sequence and the capabilities and motivation of teachers. It is, of course, possible to design a curriculum without attention to what the capacities of teachers are, but we should not expect that curriculum to fare very well in terms of transforming classroom instruction. Similarly, the way in which students and teachers are evaluated, both for the purposes of supporting improvement, as well as to assess what they have learned and taught, should be aligned with the curriculum and should connect with teachers, for instance, integrating assessment results with teacher professional development opportunities. These are all domains which AI applications could contribute to. For example, a recent study of the perceptions that 410 teachers in Brazil had of their needs, identified the need to automate their administrative demands as well as more time for study and lesson planning as salient (Ferreira et al., 2025), these are needs which AI can help address. Relatedly, a systems approach to examining the role of AI in education should consider second order and indirect impacts of AI; for example, school principals are in many places unable to devote much time to instructional leadership because administrative demands consume most of their time. If AI can help principals meet these administrative demands and therefore free up time for instructional leadership this is a salutary second order effect of AI on instruction. Similarly, assessment of student knowledge and skills often focuses on low order skills, such as short term recall, because those are easier to assess through simple multiple option tests. If AI can read student written essays and assess them using rubrics that reflect more complex cognitive competencies, this can provide students and teachers feedback on competencies that are undoubtedly more valuable than simple recall

of factual knowledge. If, on top of it, this can be done in settings that have irregular access to connectivity, this application of AI will not only support deeper learning instruction but do so in a way that does not augment inequality (Rodrigues et al., 2025).

An additional peculiarity of education systems which impacts their functioning is their size and the number of people they affect. The education system is very commonly one of the largest organizations in a society, affecting, directly and indirectly, more people than any other organization. Their large size often translates into greater complexity in operations—for instance ensuring that the various components of an improvement program such as professional development, instructional resources, new assessment approaches all converge in the schools at the same time so that they can work synergistically as expected requires complex logistics.

This is all to say that in thinking about an education system, we should see the forest (the system) at the same time as we see the trees (the elements of the system) and we should be especially attentive to how the interactions between the elements of the system translate into overall systemic performance.

1.5 What Is Artificial Intelligence in Education?

Artificial intelligence (AI), as a concept and a field of research, has evolved significantly since its inception in the mid-twentieth century. Early visions of AI were inspired by the idea of machines that could mimic or even surpass human intelligence. In 1956, at the Dartmouth Conference, the term "artificial intelligence" was formally coined, setting the stage for decades of exploration into how computers might solve problems, recognize patterns, and "think" autonomously. Initially, progress was slow, as the computational resources and theoretical frameworks needed for true machine intelligence were largely lacking. However, periodic breakthroughs—such as early rule-based systems[1] in the 1960s and expert systems[2] in the 1980s—kept researchers and futurists invested in the promise of AI.

Contemporary definitions of AI generally describe it as the development of computer systems capable of performing tasks that would normally require human intelligence (Martin et al., 2024). These tasks include reasoning, learning from experience, understanding language, recognizing patterns and images, and making decisions. In the context of education, AI encompasses a suite of technologies that can assist or even independently manage processes ranging from personalizing instruction to automating administrative work, or enabling new forms of assessment and feedback that were previously unimaginable.

[1] Basic "if-then" logic. They could only do what they were explicitly told to do in these rules, no learning or flexibility.

[2] More complex systems that mimic expert human knowledge using lots of rules.

Several subfields of AI are especially pertinent to education. Machine Learning, perhaps the most well-known, involves algorithms that learn from data and improve their performance over time without explicit programming. Machine learning powers adaptive learning platforms that respond to individual student strengths and weaknesses. Natural Language Processing (NLP) enables machines to interpret and generate human language; in education, NLP is fundamental to automated essay grading, chatbots for student support, and language learning applications. Computer Vision allows software to interpret visual information, opening possibilities for applications like automated proctoring, analysis of classroom engagement, or tools for students with visual impairments.

It is also important to distinguish between narrow or weak AI and general or strong AI. Most of the AI currently deployed in education systems globally—and anticipated in the near future—is narrow AI (also called "applied AI"), designed to perform specific tasks such as recommending assignments, classifying student responses, or analyzing attendance patterns. In contrast, general AI would require a level of reasoning, abstraction, and autonomous learning akin to human cognition—it would be able to transfer knowledge across domains and undertake a wide variety of intellectual endeavors. General AI remains a theoretical possibility rather than a reality, and for the purposes of education, present efforts are concentrated on leveraging and integrating narrow AI systems into the vast and complex processes of teaching and learning.

The focus of this book will be on the practical realities of the technologies today—not theoretical possibilities.

1.6 A Systems Approach to Studying the Role of AI in Education

It follows from the previous discussion of what it means to adopt a 'systemic' approach to education that the particular configuration of each system, resulting from the goals it is trying to pursue, from the various initiatives in place to advance those goals, from the curriculum it follows, from the kind of teachers in the system, and so on, define a context that is unique. Any introduction of AI in that system needs to respond to that singularity and attend to the interactions and feedback loops that the incorporation of AI will generate. A systems approach ensures that AI solutions are not just imported, but co-developed or adapted locally to meet the unique challenges and harness the specific strengths of each community. Such adaptation and co-development has been proposed as a general approach to transfer educational innovations across contexts (Reimers et al., 2012).

For instance, one of the considerations that should be paramount in contexts in which resources are limited, as is often the case in countries in the Global South, is how the introduction of AI in education will interact with rural-urban divides, and with historical social inequities. This makes equity a central concern, so in such

settings we should be asking not just how AI can benefit the majority, but how it can close gaps for girls, linguistic minorities, students with disabilities, and others at risk of exclusion. Similarly, plans to find ways in which AI could improve education should consider to what extent do students and teachers have access to connectivity and devices, even in settings where such access is limited; there are ways to deploy AI that require low technological infrastructure. Another example of the need for contextually relevant use of AI are considerations about the level of knowledge and skills of teachers, so that uses of this new technology are aligned with the qualifications of the teaching force.

Rather than viewing AI as an isolated tool or technological intervention, a systems approach examines how its introduction will reverberate across curriculum, teacher training, assessment, school governance, finances, and student support. For example, introducing AI-powered adaptive learning platforms in classrooms will only succeed if teachers are adequately trained, the introduction of AI is aligned to the curriculum and assessment, and school management systems can support the resulting data flows.

Adopting a systems approach to AI in education in the Global South is about understanding and leveraging the complex web of relationships within education ecosystems. It means integrating technology in ways that align with local realities, address systemic inequities, foster institutional collaboration, and build capacity iteratively. Only by considering the interacting elements—curriculum, teachers, management, finance, policy, and communities—can AI serve not just as a technological fix, but as a transformative force for more resilient, adaptive, and equitable education systems.

Therefore, adopting a systems thinking perspective to examine the implications of AI for education means approaching AI not as a standalone technological intervention, but as a component that will interact dynamically with all other parts of the education ecosystem. Such interactions are multidirectional, we have described earlier how AI should be aligned to the context formed by those elements of the education system, but similarly, the introduction of AI-powered personalized learning tools will only realize their promise if curricula, teacher capacities, assessment practices, and institutional cultures adapt in concert.

A systems thinking mindset also appreciates that educational change, including the introduction of AI, occurs within a living, adaptive, and multi-goal environment. Schools are not passive stages for implementation, but dynamic organizations juggling many priorities. Any new policy, tool, or technological advance will be interpreted and adapted by education professionals within the context of their existing tasks, beliefs, and resources. For AI to translate into meaningful transformation, it must harmonize with ongoing work and established goals, rather than being experienced as an external imposition disconnected from current realities or perceived needs. Systems thinking further appreciates that interventions may generate ripple effects or second-order effects—sometimes unexpected and far-reaching—due to the presence of feedback loops, non-linear relationships, and emergent dynamics. Small innovations may result in outsized impacts, either positive or negative, depending on how they interact with existing structures and processes.

We also draw on the Stanford Institute for Human-Centered AI's perspective that human-centered AI should be concerned not just with the effects on the user—be it a teacher or a student—but on the classroom, the community, and society at large. This perspective calls for careful attention to alignment, adaptation, and the relational webs that ultimately determine whether AI enhances learning or simply adds complexity without benefit. Thus, to harness AI's potential responsibly, educators, leaders, and policymakers must consider not just what the technology can do, but how it is integrated systemically within the fabric of the education system.

The potential of AI can only be fully realized when different parts of the system work together. In the Global South, this might mean using AI analytics to match teacher professional development with real-time student needs, connecting universities (as AI knowledge hubs[3]) with basic education through networks and training, or deploying AI-driven resource allocation to optimize limited education budgets.

Given the pace of technological change, a systems approach advocates for pilots, iterative feedback, and constant learning. This includes evaluating not only technical performance, but also social, ethical, and pedagogical impacts—especially in contexts where evidence is often scarce.

Because AI does not exist in a vacuum, its successful adoption depends on supportive policies, conducive regulatory environments, and institutional willingness to experiment. This requires coordination among ministries, local authorities, universities, and NGOs. For example, leveraging AI to personalize education may require new policies for data governance and privacy, professional development for teachers, access to technology and connectivity, and partnerships between schools and industry providers of technology.

Recent international evidence reinforces the need for a cautious and context-specific deployment of technology, including AI, in education systems—especially in the Global South. As highlighted by UNESCO's 2023 Global Education Monitoring Report, digital technology should serve as a tool that is explicitly evaluated for its appropriateness, equity, scalability, and sustainability. Technology's integration must always be guided by robust evidence of benefit to learners and must complement, not supplant, the irreplaceable human interactions between students and teachers.

The report further notes that technology in education occupies multiple overlapping roles: as infrastructure requiring sustained investment and maintenance; as a vehicle for delivery; as a competence to be learned; and as a context shaping educational planning and equity. Crucially, while technological interventions offer opportunities for improving access and outcomes, they also pose risks—including exacerbating exclusion, increasing burdens on teachers and learners, and introducing unintended harms if not carefully regulated and aligned with local needs.

A balanced perspective on what it means to be well-educated in the age of AI is essential. Rather than over-specializing in digital or technical skills, education

[3] Places, usually universities or research centers, that generate, study, and spread knowledge about artificial intelligence such as AI4D Africa (Artificial Intelligence for Development in Africa).

systems should prioritize a holistic curriculum that sustains and strengthens arts, humanities, and the cultivation of ethical, empathetic, and creative capacities. In this vision, AI and other digital tools support but do not replace teachers; professional educators become even more pivotal in guiding learners, fostering responsibility, and navigating rapid technological change.

These international insights strengthen the call for multi-level, evidence-based, and ethically conscious policies, underpinned by broad collaboration among government, industry, educators, and communities. Effective use of AI in education must always remain anchored to the needs, best interests, and holistic development of all learners—particularly in contexts where inequalities and systemic constraints are most pronounced.

1.7 Student Learning: The Core of Education

Education organizations exist to meet a variety of purposes, chief among them is providing students opportunities to learn. It is with respect to this purpose that we examine the role of AI in education, with the already noticed caveat that we see the creation of 'opportunity to learn' as the result of a 'system' and we therefore see AI as potentially impacting the entire system, and not just the most proximal determinants of opportunity to learn such as classroom instruction by teachers or interaction of students with content and instructional resources.

The remarkable achievement represented by the creation of universal opportunities to access basic education, in the form of public education, brought with it important challenges. While institutions created for the explicit purpose of instruction had existed for centuries, the evolution of education from a privilege of elites to a right for all, supported by the state, and intended to serve broader social, economic, and civic goals, is considerably most recent. The Enlightenment, the philosophical movement which proposed replacing the aspiration of salvation with the goal of self-rule and self-improvement, provided the intellectual foundation for an institution that would offer all people the opportunity to cultivate their reasoning, and access to scientific understanding, in line with the Enlightenment's ideas that science would help ordinary people transform their world. The specific contours of the history of the emergence of public education vary by country, but the common themes are state responsibility to support universal access, and education as an instrument of personal and societal progress. One of the first public education systems in Europe was established in Prussia in the eighteenth century. In Latin America, public education systems emerged as nations gained independence from Spain in the nineteenth century. Public education in the United States emerged also in the nineteenth century, as an instrument to foster social cohesion during a period of massive immigration. The global spread of public education often followed independence movements in the twentieth century. The Universal Declaration of Human Rights, adopted by the United Nations (UN) in 1948, incorporated the right to education, and UNESCO, the specialized UN agency focusing on education, culture

and science, contributed to the dissemination of public education and to support the universalization of access.

The remarkable transformation of extending access to compulsory education to most children brought new challenges in the form of greater diversity among learners, and limited capacity of schools to effectively address that diversity. When education had been a privilege reserved for children of the elite, it was possible to offer highly individualized forms of instruction to learners, largely in the form of tutors or very specialized academies. Twenty-four centuries ago, for instance, Plato, born into a noble and wealthy family in Athens, was educated by tutors in poetry, music, gymnastics, and subsequently deep philosophical training under Socrates in his late teens, followed by wide-ranging travel culminating in the establishment of his own school, the academy.

In the Ancient and Medieval Periods, in societies such as Greece, Rome, China, and India education was typically reserved for elites and conducted in private or religious settings. In the Islamic World, beginning in the eighth century, madrasas provided education in religious and secular subjects to selected boys from varied social backgrounds.

The elitist nature of education during the renaissance is illustrated in the education received by Michel de Montaigne (1533–1592), the French Renaissance philosopher and creator of the essay, who was tutored in Latin early in life and taught by his father using progressive methods that emphasized the joy of learning, before being sent to the prestigious Collège de Guyenne in Bordeaux at the age of six, to be exposed to a humanist curriculum emphasizing classical studies, rhetoric, and a broad exposure to the ancient texts of Greece and Rome.

With the creation of mass education systems the affordances of elite education where highly educated tutors could offer a rich education that catered to the individual interests and needs of the student were no longer possible. Public education systems had to find approaches that would educate many students at low cost, facing a new set of dilemmas about what to prioritize. These dilemmas facing the early period of creation of more inclusive education systems are reflected in the disparate views held by two early education reformers who advocated education for poor children: Johann H. Pestalozzi and Joseph Lancaster.

Johann Heinrich Pestalozzi (1746–1827) a Swiss educator and reformer espoused that the goal of education was to support the holistic development of the many different abilities–intellectual, emotional and physical—of each child through experiential learning and caring relationships. Pestalozzi advocated centering teaching and learning on the needs, interests and experiences of the child, adapting to their different paces and abilities.

In contrast to Pestalozzi who emphasized a broad curriculum that educated the 'whole child', Joseph Lancaster (1778–1838) advocated a foundational curriculum delivered with a 'monitorial system for the education of the poor', an approach consisting of developing a structured curriculum, focusing on the basics of literacy and numeracy, taught to small groups of students organized by age, by more advanced students under the supervision of a tutor. The approach was effective in that it leveraged the work of a single tutor with assistants (monitors) and a

structured curriculum which allowed the instruction of many children together. Because this reduced the cost of instruction, it was possible to now offer education to many 'children of the poor'. Unsurprisingly, such a standardized approach did not meet the needs of all children. Notably, an important element of Lancaster's method was disciplining children who disrupted instruction, arguably a very poor way to manage the results of an education that failed to engage students effectively.

These two perspectives remain the subject of contemporary debates on what mass education should offer learners. Pestalozzi's views became the foundation of a movement called 'progressive education', whereas Lancaster's method provided the foundation for the subsequent expansion of the public school, which relied also on a structured curriculum and in sorting students of similar ages into the same 'grades'. Public school systems also adopted a number of features of the theory of scientific management developed by American engineer Frederick Winslow Taylor to improve the economic efficiency and labor productivity of industries. This led to the standardization of education: organizing instruction during set times and periods, structuring the curriculum, standardizing instruction and the teaching profession. To this day, many public education systems are organized so that 'management' designs curriculum and work processes, while teachers are responsible for executing them, and methods, tools and processes are standardized to achieve optimal efficiency. While the idea that the public school today still follows a factory model organized according to Taylorist principles may be a bit of a caricature, the notion that the organization of schools has changed less since public education was invented a few centuries ago than the social context in which they operate, is pervasive.

1.8 How Can AI Improve the Opportunity to Learn?

As mentioned in the introduction of this chapter, we will address this question at three levels: a) how to develop AI literacy? Teaching the skills needed to navigate a world where AI is increasingly prevalent, b) how to leverage AI to improve the effectiveness of the education system? Successfully teaching the intended goals of the curriculum to all students, and c) how can AI improve the relevance of the education system? Teaching a more complex and a broader range of skills.

1.8.1 How Can AI Literacy Be Developed?

Education systems can integrate digital and AI literacy to prepare students and workers in two complementary ways. The first is by systematically embedding opportunities within the curriculum for learners to develop both procedural and conceptual understanding of AI. This includes the knowledge of how AI works and the ability to develop AI, the ability to use AI tools and platforms, as well as an understanding of the strengths, limitations, and societal implications of AI. The

second is by deploying AI in the service of education itself—using AI-driven tools and platforms to support and personalize the learning environment, thereby enabling students to develop familiarity with AI through direct, practical engagement as learners.

Integrating AI into education requires deliberately incorporating topics such as coding, machine learning, data science, robotics, and neural networks into the curriculum. Cultivating the ability to use AI tools and platforms, involves engaging students in the use of large language models in various ways, or experiencing AI-assisted modes of interaction with content, such as AI-powered textbooks or other modalities to personalize the curriculum. Like any other domain, the development of AI literacy should begin with foundational lessons in early education and progress to more advanced study in higher education. Importantly, opportunities to learn about AI should not be siloed but woven throughout the curriculum and addressed across subjects.

A comprehensive competency framework is essential for guiding these curriculum efforts. Such a framework should extend beyond teaching technical skills like coding or prompt engineering, to include fostering critical thinking and problem-solving abilities. It should help learners interrogate the strengths and constraints of AI and encourage them to reflect on the ethical implications of its use—issues such as data privacy, algorithmic bias, and broader societal impacts—ensuring they understand the responsibilities associated with developing and using AI technologies. An example of the need for policy frameworks to guide this work is the ongoing effort of the Council of Europe to develop a compass for AI in Education which "aims to translate Council of Europe standards into concrete action. It will offer structured guidance to help member states, education institutions, teachers, students, and private sector actors implement responsible, ethical, and human-centric uses of AI in education, in line with the principles of human rights, democracy, and the rule of law" (Council of Europe, 2025).

A curriculum, however, is not self-executing. Integrating AI education requires robust professional development for teachers. Educators must develop their own understanding of AI and learn how to incorporate it effectively into their practice. Effective professional development should be job-embedded, sustained over time, and include opportunities for collaborative learning and peer support.

Equally important is the adoption of engaging and effective pedagogical approaches. Practical, hands-on experiences—such as project-based learning—are particularly valuable for developing AI literacy. Schools should exemplify best practices by deploying AI tools not only to support student learning (e.g., AI tutors, educational software) but also to assist teachers, for instance through analytics that personalize instruction and provide just-in-time professional development.

As students advance, partnerships between schools and industry—providing mentorship, internships, and real-world learning opportunities—can deepen understanding and help bridge the gap between education and workforce needs.

For these efforts to be successful, coherent government policy is required, particularly to support the necessary investment in infrastructure and digital learning environments.

Research demonstrates that educational systems can build digital and AI literacy through coordinated curriculum reform, active learning methods,[4] and enhanced teacher training. For example, Estonia's ProgeTiger programme embeds AI skills from pre-school through higher education, while university courses increasingly combine theory with project work to foster both technical competence and critical thinking. In primary and secondary settings, weekend workshops and digital game-based approaches have been found to improve students' understanding of AI concepts and ethical reasoning.

Studies repeatedly indicate that structured teacher support and interdisciplinary strategies further enrich learning. Best practices include:

- National or curriculum-wide AI literacy integration spanning multiple educational levels
- Hands-on learning experiences, such as workshops, game-based activities, and project-based learning, to build technical skills and critical analysis
- Comprehensive teacher training to foster digital and AI teaching competencies

Most studies document positive outcomes, such as enhanced Information and communications technology (ICT) skills, increased understanding of AI, higher confidence in using technology, and stronger ethical reasoning. These findings support a multifaceted approach to equipping learners with the skills necessary to utilize and benefit from artificial intelligence.

1.8.2 Curriculum Integration of AI Literacy

Integrating AI literacy into the curriculum is a major theme emerging from recent studies. Approaches vary widely in scope and implementation. Estonia's ProgeTiger programme serves as a compelling example of a systemic approach to developing digital skills, including AI literacy, throughout a student's educational journey. At the university level, initiatives described by Chaushi et al. (2024) and Walter (2024) highlight the benefits of combining theoretical instruction with practical application and underscore the need for interdisciplinary approaches. For secondary education, research indicates that collaborative, project-based learning is particularly effective, supporting the view that AI literacy is best taught as an integrated component of various disciplines rather than as an isolated subject.

[4] Teaching approaches that engage students directly in the learning process through activities like discussion, problem-solving, or group work, rather than passively receiving information.

1.8.2.1 Pedagogical Approaches and Tools

A diverse array of pedagogical methods and tools is being used to teach AI literacy, with a strong emphasis on practical, hands-on learning. Project-based assignments, workshops, and games engage students and foster both technical proficiency and critical thinking.

Implementation Challenges

The studies highlight several persistent challenges in implementing AI literacy:

- Teacher preparedness: Many educators require targeted professional development and support to build the confidence and competencies necessary to teach or utilize AI effectively.
- Resource constraints: Delivering AI literacy education often depends on technological resources that are not equally distributed, especially in contexts marked by a pronounced digital divide.
- Curriculum integration: Balancing the addition of AI content to existing curriculum requirements is a complex task. Systemic approaches, like Estonia's, offer valuable insights.
- Assessment methods: Designing assessment tools that adequately capture both technical and non-technical AI competencies—such as ethical and critical reasoning—is an ongoing challenge.

Proposed Solutions

- Comprehensive teacher training: Evidence shows that well-designed professional development can significantly enhance teachers' confidence and ability to teach AI literacy.
- Adaptive learning technologies: Personalized, adaptive AI-driven resources can help overcome resource constraints and tailor learning to diverse student needs.
- Interdisciplinary methods: Integrating AI literacy across subjects through project-based learning fosters deeper understanding.
- Diverse assessment strategies: Employing both quantitative and qualitative tools enables a more nuanced evaluation of students' AI competencies.

1.8.3 What Makes Us Uniquely Human? Mitigating Workforce Displacement Risk

What strategies and policies can be implemented to mitigate the risks of workforce displacement caused by AI? The most immediate impact of AI is its potential to replicate and replace routine and analytical tasks, often found in many

middle-income jobs. However, job roles are also likely to evolve, increasing the importance of working in partnership with AI as a form of "co-intelligence" rather than outright replacement (Mollick, 2024).

Supporting this shift will require a robust focus on lifelong learning, upskilling, and reskilling, with educational and workforce development programs integrating digital courses and resources that are accessible to adults at every stage of their careers. Career transition assistance, such as counseling, job placement services, and financial support for retraining, can help workers adapt to changing labor market demands. For those most affected by displacement, social safety nets—perhaps in the form of Universal Basic Income (UBI) or enhanced unemployment and health benefits—may be necessary to bridge the gap during periods of transition.

Research confirms that structured reskilling programs, especially those grounded in systematic analyses such as the ADDIE model, an acronym for Analysis, Design, Development, Implementation, and Evaluation, improve knowledge retention and job placement outcomes. This model provides a structured approach to developing effective and engaging learning experiences. One study found a 64% increase in retention when training was delivered proactively rather than reactively. Educational reforms embedding data, technology, and human literacy across all levels also help workers adapt to automation and new work processes.

Complementary policies at governmental and organizational levels—such as income support, ethical AI regulations, and strong public-private partnerships—foster a supportive environment for workforce adaptation and minimize the risks of displacement.

1.8.3.1 Policy Framework Solutions for Workforce Displacement

Multiple policy and regulatory approaches have been proposed or piloted:

- Government interventions: Basic Income schemes funded by special taxes on industries using AI, closer partnerships between government, employers, and educational institutions, and the establishment of dedicated workforce education offices.
- Regulatory measures: Guidelines and regulations to ensure the ethical use of AI, with an emphasis on fairness and inclusive growth, like the European Union's AI Act.
- Economic support systems: Expanded safety nets, including UBI and subsidized retraining programs, to provide stability for displaced workers.

How can governments and industries collaborate to promote continuous learning and adaptability among workers? Several effective strategies emerge:

- Public-private partnerships (PPPs): Joint training programs, co-developed by industry and government, ensure that education and training align with current and future labor market needs. These may be offered via vocational schools, colleges, and online platforms.

- Lifelong learning infrastructure: Mapping industry skills needs, informing curriculum development, and creating clear pathways for reskilling and career development are key. Providing incentives for ongoing learning, and investing in learning infrastructure, helps keep workers adaptable.
- Regional and sectoral initiatives: Tailored programs addressing the needs of specific industry sectors, and regional collaborations that share resources and best practices, are both essential in addressing local workforce priorities.
- Fostering a culture of learning: Public awareness campaigns and active engagement by industry leaders can help shift mindsets among both employers and workers, underlining the necessity of continuous learning.

By clearly defining roles, coordinating policies, and leveraging shared platforms, governments and industries can build robust ecosystems for lifelong learning and adaptability. Cases from around the world demonstrate the value of policy-driven models, technology-enabled learning solutions, and cross-sectoral collaboration in modernizing workforce training.

1.8.3.2 Government-Industry Partnership Models

Studies present a spectrum of partnership models for promoting continuous learning and adaptability:

- Policy-driven collaboration: Government leads policy coordination, while industry assists with service delivery and responsiveness to workforce needs.
- Platform-based partnerships: Leveraging digital platforms (such as Massive Open Online Courses—MOOCs) at scale, often in cooperation with universities and industry.
- Research-driven collaboration: Government and research institutions co-develop advanced online training using the latest ICT tools.
- Industry-university partnerships: Collaborative lifelong learning programs combine academic expertise with practical industry requirements.
- Regional governance frameworks: Multi-stakeholder initiatives that tailor workforce development to regional or local needs.

The effectiveness of each model depends on context, scale, and the institutional frameworks in place. Studies underscore that success relies on clear role definitions, the strategic integration of technology, and broad-based involvement of relevant stakeholders.

1.8.3.3 Technology-Enabled Learning Solutions

Recent experience points to several advantages of technology-enabled learning, including scalability, flexibility, customization, and the capacity for real-time updating of content to match workforce needs. While more research is needed to compare

these solutions with traditional approaches, early findings suggest that digital platforms, advanced ICT tools, and a focus on digital skills development are crucial enablers for lifelong learning in the age of AI.

1.8.3.4 Regional Collaboration Mechanisms

Regional collaboration plays a vital role in promoting workforce adaptability. Initiatives such as the Ottawa TalentWorks program emphasize regional learning and governance structures that bring together government, industry, educational institutions, and communities to address specific workforce challenges. Regional and sectoral programs can fine-tune workforce training to meet local priorities and economic goals, enhancing the relevance and impact of continuous learning strategies.

1.9 Conclusion

In this chapter, we explored the transformative potential of AI in education, focusing on how it can enhance learning opportunities, improve educational systems, and prepare students for a rapidly evolving world. We discussed the importance of developing AI literacy, leveraging AI to enhance educational effectiveness, and improving the relevance of education systems. The integration of AI into education requires a multifaceted approach, including curriculum reform, teacher training, and the adoption of engaging pedagogical methods.

The successful integration of AI requires addressing issues such as teacher preparedness, resource constraints, and the need for coherent government policies.

As we move forward, it is crucial to adopt a systems approach that considers the dynamic interplay between various components of the education system.

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Chapter 2
Challenges and Opportunities of Education in the Global South

2.1 Access: Spectacular Gains, Uneven Realities

The story of access to education over the past 75 years is, in many ways, a remarkable one. In 1948, the right to education was formally recognized in the Universal Declaration of Human Rights, at that time, for millions of children across the Global South, education was a distant promise. Since then, the world has witnessed a dramatic transformation. Primary school enrollment now exceeds 90% globally (UNESCO, 2021), and far more children, especially girls, are stepping into classrooms than ever before. The days when nearly two-thirds of out-of-school children were girls are no longer the norm. Major gains have been made toward gender parity in primary education.

A visit to a rural village in sub-Saharan Africa or an overcrowded urban settlement in South Asia, will quickly evidence that these global averages tell an incomplete story. In these communities, school doors remain shut for far too many, especially adolescent girls. Amina, a 13-year-old in northern Nigeria, dreams of becoming a nurse but walks past the village school each morning because her family cannot afford the fees, or because her safety on the way to school is not guaranteed. She is one of the 251 million children and youth still out of school in the Global South (UNESCO, 2024a).

Furthermore, educational access is not just about enrolling in school. It is about whether children can attend regularly, feel safe, be included, learn, and complete their education (Reimers, 2000). UNESCO (2005) emphasizes that access must include dimensions of quality, safety, and support, especially for marginalized groups facing hidden barriers like hunger, disability, unsafe routes to school, or instruction in unfamiliar languages. In many contexts, children arrive at school without the foundational readiness to benefit from learning, particularly where early childhood education is lacking.

Even though preschool participation has grown impressively, from just over 15% in 1970 to over 60% in 2019 (UNESCO, 2021), access to this level of education

F. Reimers et al., *Artificial Intelligence and Education in the Global South*,
https://doi.org/10.1007/978-3-032-11449-5_2

remains highly unequal. In low-income countries, millions of young children still miss out on early learning opportunities. This stage of education, critical for brain development and lifelong learning, remains chronically underfunded and out of reach for those who need it most (World Bank, 2025).

While the expansion of access to education is one of humanity's great achievements, it remains an unfinished journey. Some hope AI-powered tools to support learning, which we will explore in Chap. 3 "Students, classrooms and schools", can help address this access crisis by ensuring that more children enter school and are better supported to learn.

2.2 Learning Outcomes: The Global Learning Crisis

While access has expanded, opportunity to learn remains a critical concern. The World Bank, in partnership with UNESCO's Institute for Statistics (UIS), has defined "learning poverty" as the percentage of 10-year-olds unable to read and understand a simple, age-appropriate text. A child with minimum reading proficiency should be able to comprehend a short passage, such as a story about a girl planting a tree, a paragraph describing her morning routine, or a brief nonfiction narrative. As of 2022, the learning poverty rate was estimated to be at 70% in low- and middle-income countries and nearly 90% in Sub-Saharan Africa, a sharp increase due to the pandemic (World Bank, 2022).

In low-income countries, more than two out of five women are not literate, and one in four young people cannot read or write (UNESCO, 2021). But what does that really mean? For a mother, it may mean not being able to read a medicine label or the instructions to administer the medication to her child, or to write her name on a government form or understand what she is signing. For a young person, it can mean being unable to fill out a job application, read safety instructions at work, or vote in an election having understood what different candidates propose or represent. Illiteracy limits more than just economic opportunity, it affects dignity, voice, and autonomy. It shapes how people navigate daily life, whether they are safe in emergencies, how they access public services, or whether they can help their own children with schoolwork.

Even among those in school, many do not acquire basic skills: international assessments of students' knowledge and skills reveal that large shares of 15-year-olds cannot understand texts beyond the most basic level, and more than one in four lower-secondary and one in two upper-secondary students do not complete those education levels (UNESCO, 2021). Foundational learning in the early grades is especially weak in many countries. According to the 2025 Global Monitoring Report, millions of children finish primary school without mastering basic literacy or numeracy skills, particularly in low-income contexts. The report also highlights the importance of mother-tongue instruction during the early years, a proven yet often overlooked approach to improving learning outcomes as in many countries students are taught in a language which is not the language they are conversant in at

home. Strengthening early-grade teaching and language policies is among the most effective and equitable ways to raise learning outcomes (UNESCO, 2025).

The opportunity cost of inaction is high: UNESCO estimates that if all children in low-income countries left school with basic reading skills, 171 million people could be lifted out of poverty (UNESCO, 2014). The World Bank further notes that the COVID-19 pandemic has led to the largest disruption in education in history, with this generation of children projected to lose a combined $21 trillion in lifetime earnings because of the limitations placed in their skill development (World Bank, 2025). But beyond the economic costs stemming from low-quality education, there are moral and social costs as well. A child who finishes school without learning to read or count represents not just a missed opportunity but a violation of their right to education, a perpetuation of inequality, and a barrier to full participation in society. Such lack of basic skills limits their ability to find dignified work, make informed decisions, advocate for themselves and their communities or support their own children with their education and development.

Ensuring that all children in fact learn in school, at scale, will require sustained investment in teachers, central actors in any education system, and it is possible that thoughtful integration of AI tools could support teachers in their work, a possibility we explore in Chap. 6.

2.3 Equity and the Web of Exclusions

Today's gaps in access, participation, and outcomes are based on yesterday's exclusions (UNESCO, 2021). Poverty, gender, disability, ethnicity, language, and conflict create a "web of exclusions" that systematically marginalize certain groups. In sub-Saharan Africa, for every 100 boys of primary school age out of school, there are 123 girls also excluded. Girls from the poorest households in the lowest-income countries spend, on average, 2 years less in school than boys (UNESCO, 2021). Gender inequality in education goes beyond enrollment. UNESCO's 2024 Gender Report "Technology on Her Terms" shows that while women make up a large share of the teaching workforce, they remain underrepresented in leadership positions. For instance, only 46% of countries have achieved gender parity among primary school heads, and just 23% have done so at the upper secondary level (UNESCO, 2024c). The report also highlights that boys continue to lag behind girls in reading skills: globally, for every 100 girls proficient in reading, only 87 boys reach the same level, and in middle-income countries, the gap widens to just 72 boys per 100 girls. Meanwhile, women remain underrepresented in STEM fields; they make up only 35% of tertiary graduates in STEM and just 25% of researchers globally. In technical and vocational education, gender gaps also persist, with women comprising only 43% of participants globally, and lower rates in many low-income countries (Fig. 2.1).

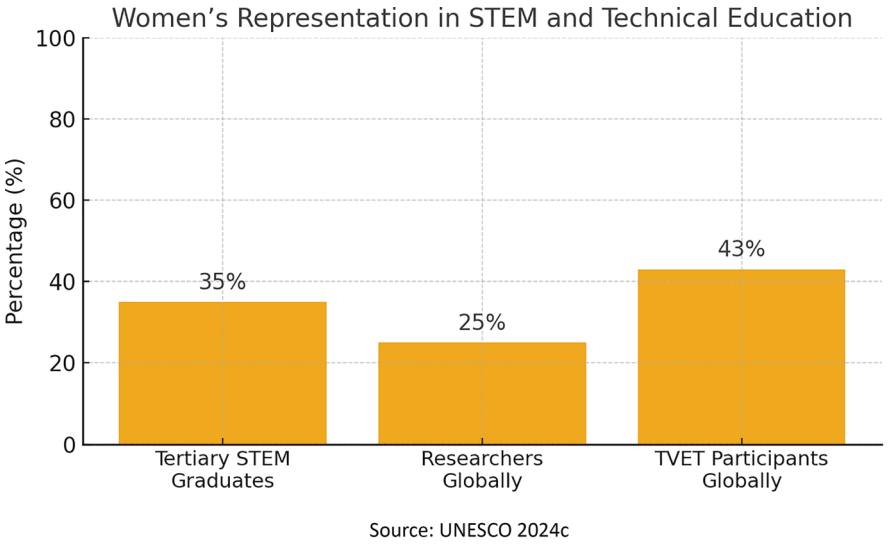

Fig. 2.1 Women's representation in STEM and technical education

These patterns show that gender gaps are not only about who gets to attend school, but also about who learns what, who leads, and who benefits from the skills taught in education systems (UNESCO, 2024a, 2024b).

Children with disabilities, indigenous and ethnic minorities, and those in conflict zones face compounded barriers. Poverty remains a key determinant of educational opportunity, intensifying disparities for girls, children with disabilities, those in unstable environments, and marginalized ethnic or linguistic groups (World Bank, 2025).

Disability remains a significant barrier to education across all regions and income groups, especially when inclusive policies are lacking. Most children living with a disability are in poorer countries, where poverty both causes and is a consequence of disability. Poverty and disability are interconnected, with poverty contributing to conditions that can cause disabilities, while disabilities can also lead to economic hardships that perpetuate poverty. Since effective inclusion of students with disabilities is less available to poor students, this compounds the marginalization of disabled students who live in poverty.

Another condition which undermines educational opportunity is conflict and the associated displacement. Children in conflict zones represent half the world's chronically out-of-school population, as violence, displacement, and instability disrupt education (UNESCO, 2021). Already in 2011, a report highlighted horrific practices (including targeted bombings, sexual violence, and the occupation of schools by armed actors) that lead to widespread trauma and permanent disruption of schooling (UNESCO, 2011). Such assaults not only force mass school closures and mass displacement but also erode the trust that students, particularly girls and vulnerable groups, place in education systems. Yet despite the critical role schools

play in protecting children and communities, education spending as a share of GDP has decreased from 4.5% in 2010 to 4.3% in 2022 (World Bank, 2024b). Embedding education in peace-building efforts, better safeguarding learning spaces, and amplifying humanitarian funding are therefore essential steps toward securing continuity and safety in education amid armed conflict.

Indigenous and ethnic minority children face additional barriers, including racism, discrimination, lack of cultural relevance in curricula, and forced assimilation. Large-scale assessments often fail to account for mother-tongue competencies, further marginalizing these students. Addressing these equity challenges is crucial, and if AI tools are to be relevant to these problems, as we will discuss in Chap. 4 "AI and curriculum", they must offer potential solutions to create more inclusive educational opportunities for these most marginalized groups of children.

2.4 The Teacher Workforce: Professionalization and Regression

Teachers are the most significant contributors to educational quality. Ideally, they should have sufficient recognition, preparation, support, resources, autonomy, and opportunities for continued development (UNESCO, 2021). Yet, as access to schooling has grown rapidly, there has also been a worrying regression in the share of qualified primary school teachers, especially in sub-Saharan Africa, where the share declined from 85% in 2000 to about 65% in 2020. At the secondary level, only half of teachers in sub-Saharan Africa possessed minimum qualifications in 2015, down from nearly 80% a decade earlier. Inadequate teaching quality and weak governance are persistent challenges in basic education (World Bank, 2024a). Enhancing teacher professional development through AI, a topic we will explore in Chap. 6, could provide innovative solutions to these challenges.

2.5 Financing, Poverty, and Inequality

Poverty remains a key determinant of access to educational opportunity, intensifying disparities. Despite global economic growth and reductions in poverty rates, extreme poverty is still concentrated in sub-Saharan Africa, disproportionately affecting women and children (UNESCO, 2021), while global annual per capita income increased by 75% between 1990 and 2020, close to 690 million people still live in poverty, and a quarter of the world population, some 1.8 billion people, live on $3.20 or less per day (World Bank, 2025). Two-thirds of those who are poor are children and youth under 25 years of age.

Education financing remains both inadequate and badly targeted: low-income countries spend only $55 per student per year, and public debt service is crowding

out investment in education (World Bank, 2024a, 2024b). Extreme inequality can also breed corruption in education, from diversion of resources to bribery and nepotism, further disadvantaging the poor (UNESCO, 2021). Government ministers and the international community are promoting and supporting innovative financing mechanisms such as outcomes-fund that mobilize additional, more equitable and more efficient allocation of financial resources (Education Outcomes Fund, 2025). Unlike traditional financing models, these funds tie payments to the achievement of measurable outcomes such as improvements in literacy skills or job placement and retention, rather than activities or outputs. Often managed in partnership with governments, outcomes funds pool resources from public and private actors, contract multiple service providers, and pay only when pre-agreed outcomes are independently verified. In 2022, the Government of Sierra Leone, in collaboration with the Education Outcomes Fund (EOF), launched the Sierra Leone Education Innovation Challenge (SLEIC) with a budget of US$18 million. SLEIC pooled funding from the Government of Sierra Leone, UK Aid Direct, Korea International Cooperation Agency, Bank of America and the Hempel Foundation. SLEIC aims to enhance the learning outcomes for 134,000 children aged 6–12 in government schools across Sierra Leone. Over 3 years, SLEIC will pay for the outcomes achieved. Though still in its early stages, SLEIC's initial results are promising (Education Outcomes Fund, 2025). To diversify financing, outcomes-funds have emerged.

Can AI support the achievement of these necessary improvements? While AI alone is not sufficient, it can be part of a broader policy mix to improve educational outcomes. AI-driven financial models, which we will discuss in Chap. 8 on "AI and Education Governance," offer potential solutions to optimize resource allocation, enhance decision-making, and improve educational outcomes. By leveraging data analytics and predictive modeling, AI can help identify the most effective interventions and ensure that resources are directed where they are needed most.

2.6 Relevant Curriculum

A major challenge in the Global South is the relevance of education to students' lives and future opportunities. Many education systems continue to emphasize rote memorization and passive learning, leaving students ill-prepared for employment or civic engagement. Curricula often lack cultural relevance, especially for indigenous and minority students, and large-scale assessments rarely account for mother-tongue competencies (UNESCO, 2021). Students may be forced to assimilate into dominant cultures at the cost of their identities. There is a need to embrace diverse ways of knowing, including indigenous knowledge systems, and to foster greater cultural and linguistic inclusion. Additionally, many education systems remain disconnected from the realities of labor markets, particularly in low- and middle-income economies, where informal employment is widespread (World Bank, 2019). Informal apprenticeships exist, but are poorly supported by formal institutions. This shows the mismatch between education systems and labor markets, especially for youth

outside the formal economy. AI has the potential to bridge this gap by creating more relevant and adaptive curricula, a topic we will explore in Chap. 4.

2.7 Systemic Disruptions: Migration, and Climate Change

Migration, and emergencies, including pandemics and climate change, pose significant threats to educational continuity and equity. Educational institutions, personnel, and students are often targeted or displaced, and the COVID-19 pandemic caused the largest disruption in education in history, affecting 1.6 billion learners worldwide (UNESCO, 2021; World Bank, 2025). Even as schools reopen, millions of students, especially those from poorer and more marginalized communities, may never return, further exacerbating inequality.

Climate change and environmental disasters also disrupt schooling, particularly for the most vulnerable populations. According to UNESCO's 2024 Global Education Monitoring (GEM) Report, while climate-related events (such as floods, droughts, and heatwaves) already displace millions, 32.6 million internally in 2022, few countries have national laws or curricula that effectively prepare students for these shocks. The 2024 UNESCO GEM Report reveals that education's role in climate action is often sidelined, and SDG 4 was addressed in only 2 of 72 transnational climate initiatives. Even where climate education is included, national curricula give it limited space: across 76 countries, green content in curricula reached only half of the maximum possible score, and words related to "biodiversity" and "climate change" scored as low as 12% and 21%, respectively. Younger students are exposed to even less content (UNESCO, 2024a). Yet, education plays a vital role in shaping adaptive capacity. In Pakistan's Khyber Pakhtunkhwa province, farmers with lower secondary education were more likely to adapt their practices in response to climate-related threats than those below those levels of education. In Bangladesh, a school stipend program for girls significantly reduced fertility rates and enhanced climate resilience through demographic transition. As youth movements demand more just, relevant, and empowering climate education, the global community must ensure that curricula move beyond knowledge transmission to foster the skills, attitudes, and agency needed for mitigation and adaptation in an era of escalating climate risk (UNESCO, 2024a).

New global risks are creating serious challenges for education systems, especially in low- and middle-income countries. The World Economic Forum (2025) highlights that armed conflict and extreme weather are the top two global risks for the coming year. These threats can close schools, displace students, and destroy infrastructure. The report also warns that false information and fake news are growing threats. This makes it harder for people to trust experts and public systems, including education. In the long term, digital risks like cyberattacks and the misuse of artificial intelligence are expected to increase. As schools become more connected, protecting students' data and teaching digital safety will be more important. Finally, rising tensions between countries may reduce funding and international

cooperation in education, which many low-income countries depend on. All of these risks show why education systems must become stronger, more flexible, and ready to respond to new global challenges. Building resilient education systems that can withstand and respond to such shocks is an urgent priority for the future (UNESCO, 2021). AI policies, which we will explore in Chap. 8 "AI and education governance", offer potential solutions to enhance the resilience and adaptability of education systems.

2.8 The Digital Divide and the Role of Technology

While digital technologies and AI hold promise for expanding access to education, personalizing learning, and supporting inclusion, the digital divide remains a significant barrier. This divide not only creates a gap between those with and without access to technology but also leads to a vicious cycle: the more access you have to technology, the more you learn and prepare for the future, whereas less access means less preparation and readiness for future challenges. For instance, in sub-Saharan Africa, only 22% of primary schools have electricity, and just 28% have internet access (UNESCO, 2020). Similarly, in rural India, only 18.47% of schools have internet access (Medianama, 2024). These infrastructure gaps mean that many learners, particularly those in rural and low-income communities, simply cannot benefit from the tools and innovations being developed.

Introducing advanced technologies into already unequal systems can exacerbate these gaps. Students who face barriers due to poverty, gender, disability, or language are likely to be the last to access and benefit from digital learning. Meanwhile, more advantaged students surge ahead. Without basic infrastructure, teacher support, and inclusive design, technology may widen the divide it aims to close. According to the Global Partnership for Education (GPE), two-thirds of teachers feel they do not have the skills to design and facilitate digital learning. As noted by the World Bank and UNESCO, equity must be a central concern in educational technology planning. Otherwise, innovations risk reinforcing the very inequalities they are meant to solve (GPE, 2025).

Most evidence of AI's impact in the Global South comes from pilot projects or small-scale studies. Large-scale implementation, rigorously evaluated impact remains limited (Trucano, 2018; UNESCO, 2020). Therefore, technology must be integrated thoughtfully, ethically, and with attention to local context and needs. It should not be seen as a shortcut but as part of a broader strategy. In India, for example, while access to the internet can be inconsistent, 80–90% of people own a smartphone across urban and rural areas. This widespread smartphone ownership provides an opportunity to utilize AI in digital tools that require low connectivity, such as WhatsApp or Telegram. Where there is access to technology, AI must seize that opportunity.

While digital technology and artificial intelligence have been widely promoted as pathways to educational transformation, UNESCO's recent report on Technology

in Education (2023) cautions that, without deliberate attention to equity and context, technology often widens rather than narrows educational divides.

The report highlights the persistence of the digital divide: inequalities in access to electricity, internet, devices, and digital skills remain particularly stark in low- and middle-income countries. As a result, technology-based innovations risk excluding marginalized students—especially those in rural areas, learners with disabilities, girls, and learners from the poorest households. This can undermine not only access but also meaningful participation in learning.

UNESCO further warns that, when not anchored in local needs, culture, and language, technology-enabled curricula may reinforce a disconnect between education and students' lived realities or labor market opportunities. Imported digital content and AI-driven solutions must be carefully localized, represent diverse forms of knowledge, and be designed with genuine input from communities.

Crucially, the success of any technology or AI intervention depends on investing in teacher development and robust, contextualized support—for teachers are the linchpin of equitable, effective learning experiences. Quick technology fixes cannot substitute for the deeper, systemic work of resourcing schools and empowering educators.

Finally, the report underlines governance and child protection as essential. As data and technology use surge in under-regulated contexts, robust oversight is needed to safeguard student privacy and prevent commercial exploitation or harm, especially for vulnerable learners.

Taken together, these insights stress that transformation in education systems in the Global South must be systemic, sustainable, ethically grounded, and always oriented first toward improving equity, inclusion, and local relevance.

2.9 Towards a New Future for Education

In a world shaped by technological disruption, climate crisis, migration, and shifting demographics, education systems face immense pressure to adapt. Organizations like UNESCO and the OECD have offered frameworks to reimagine the future of education—grounded in human rights, social justice, and cultural diversity (UNESCO, 2021), and sensitive to the uncertainty and complexity of our times (OECD, 2020). Grounded on those frameworks, this book offers a perspective that centers the Global South and asks how artificial intelligence might support—not define—a more inclusive and resilient future for learning.

The OECD's "Four Scenarios for the Future of Schooling" (Fig. 2.2.) provide a useful starting point for this reflection (OECD, 2020). These scenarios are not predictions, but imaginative tools to stimulate critical thinking about what could happen—and what we may want to happen:

"Schooling Extended" imagines a future where schools remain central but are strengthened through global cooperation, digital infrastructure, and improved

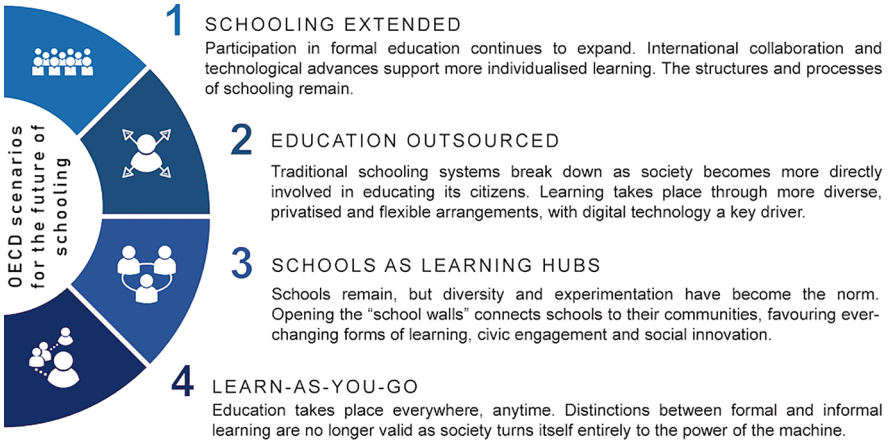

Fig. 2.2 OECD's four scenarios for the future of schooling

pedagogy. AI could play a role here by supporting teachers, personalizing learning, and expanding access—without replacing traditional institutions.

"Education Outsourced" envisions a shift away from formal schooling toward privatized, tech-driven solutions. Families increasingly rely on learning platforms, private tutors, and micro-credentials. While this might increase flexibility and innovation, it also risks deepening inequality, especially where public systems are under-resourced.

"Schools as Learning Hubs" portrays schools as deeply connected to their communities—centers not just for instruction, but for health, civic life, and lifelong learning. AI could support this model by helping schools respond more effectively to local needs, coordinate services, and engage families in new ways.

"Learn-as-You-Go" imagines a society where learning is fully embedded in daily life. Formal schooling dissolves as individuals continuously access personalized content through ubiquitous technology. In this world, AI plays a central role, but raises urgent questions about equity, privacy, and what it means to learn together.

Each of these scenarios raises possibilities—and tensions—that are particularly relevant for education systems in the Global South. They invite us to ask: Which futures are already taking shape? Which ones reflect the aspirations of our communities? And which ones might leave the most vulnerable learners further behind?

Rather than choose a single narrative about the future, this book takes inspiration from across these scenarios to propose a set of guiding principles for shaping education in an AI-enabled world.

In the chapters that follow, we explore how AI might contribute to more inclusive, responsive, and sustainable education systems. But we also ask: What values shape the use of these tools? Who benefits, and who is left out? And how can countries in the Global South harness technology on their own terms, to build futures worth striving for?

2.10 Conclusion

In the last 50 years, more children in the Global South have gained access to education, but deep inequalities remain in who is excluded and in opportunity to learn. Poverty, gender, disability, conflict, and a lack of technology continue to prevent many learners from getting a quality education. Solving these challenges will require better policies, fair funding, community involvement, and new ways of teaching and managing schools. Can AI help to address some of these gaps? This is the guiding question we take forward into the rest of this book. Theoretically, AI can support teachers, make learning more personal and fair, improve how schools are managed, and help reach students who are often left out. We will examine what the evidence says so far about the extent to which applications of AI to education are addressing these gaps.

In this book, we will explore how AI can play a role in improving education systems, while also looking closely at its limits and risks. We will see how AI might help teachers get better training, make curricula more relevant, and help schools respond to crises.

Our goal is to understand how AI can support education systems that are fair, inclusive, and ready for the future, helping all learners reach their potential and creating more just societies (UNESCO, 2021; World Bank, 2025).

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Chapter 3
Students, Learning, Classrooms and Schools

3.1 Introduction

As discussed in the preceding two chapters, among the various goals of schools, in this book we prioritize creating opportunities for students to learn. Consequently, an exploration of the possible uses of artificial intelligence in education should begin with the learners, recognizing who they are, what their experiences in schools are, what do they in fact learn, or not learn, and what challenges they face, to then discuss how AI applications could address those challenges. We then review the evidence on the extent to which AI is addressing those challenges, and then delve into the ethical questions raised by these applications and possibilities, concluding with a series of research questions. We begin with the assumption that the most proximal influences in learning are the interactions that students have with instructional content, facilitated and mediated by their teachers and by their peers. In 1963, John B. Carroll formalized a framework to conceptualize how students learn in schools, known as the Carroll Model of School Learning, proposing that learning is a function of engaged learning time and that, given the right conditions, most students could master a subject. Carroll suggested that learning is a function of the time spent on learning relative to the time needed to learn. He argued that there were five key variables defining such function: (1) the amount of time a student needed to learn content (aptitude), (2) the actual time allocated to learn it (opportunity to learn), (3) the amount of time the student actually spent learning (perseverance), (4) the effectiveness of teaching (quality), and (5) the extent to which the student understood the instruction (ability) (Carroll, 1963). Two corollaries of this model were that given enough time, all students could master any content, and that differences in learning were a function of opportunity to learn, not of differences among students.

F. Reimers et al., *Artificial Intelligence and Education in the Global South*,
https://doi.org/10.1007/978-3-032-11449-5_3

3.2 Who Are the Students in Schools in the Global South and What Challenges Do They Face?

The result of the considerable expansion in access to compulsory education which resulted from inclusive education policies over the last decades in the Global South is the large heterogeneity of the student body. Literally students from all walks of life now attend school, many of those students soon exceeding the levels of education their own parents were able to reach, experiencing an intergenerational mobility which expresses the progress resulting from recent reforms. There are students from different socio-economic circumstances, who live in different situations, in urban as well as in rural areas, who receive vastly different levels of support from their families with their studies, and who have to contribute differently to the sustenance of their families. As a result, different students face very different conditions in terms of how much time they can dedicate to their studies, and even how regularly they can attend school. Because schools are limited in offering students, particularly those most marginalized, the necessary supports for learning, these differences in socioeconomic inequality often result in inequalities in opportunity to learn, as discussed in Chap. 2. Given these differences in how much support students receive at home, the same education conditions, the same curriculum, the same teachers, the same instructional supports, may not be sufficient to provide all students with opportunities to learn which are equivalent. For example, a girl who attends school in a rural area and who must devote part of her time to fetch water for home, or wood to cook, or to devote time to care for her siblings, and who attends school irregularly given these demands, may be constrained in how much she can benefit from instruction in school. Whereas the same instruction may be much more adequate for another student not facing similar constraints. The COVID-19 pandemic, during which public education systems had to rapidly improvise alternative means of delivery, laid bare how significant these socioeconomic inequalities were in shaping the educational opportunities facing different students and how the different levels of support students received at home mediated the impact of the supports that schools were able to provide in opportunity to learn.

In addition to these differences among students, which are expressed among different countries, among students in urban and rural areas, among students sorted into different schools or even among students in the same schools, there are differences resulting from the different interests or abilities of students. Different students are interested in different topics and subjects, some of them learn more effectively from experience, some prefer to read fiction than non-fiction, some students learn faster than others, some face greater challenges in learning certain skills, such as decoding printed words or processing information.

One of the criticisms of public education systems is that, as a result of the standardization which allowed them to offer education for all, they are unable to address those differences, unable to personalize the way tutors who work with individual students, as was customary for children of the elites, are able to do. In most classrooms around the world the dominant pedagogy is whole class instruction, with

teacher talk taking up a considerable proportion of the instructional time, and with limited opportunities for students to respond to the new material, or to receive feedback on their understanding or to self-direct their learning, for instance pursuing questions or projects of their own choosing. When teachers lecture or prepare classes, one of the decisions they must make is to what type of student to 'pitch' the class. Since classes are heterogeneous, those who don't fall close to the level for which the class has been prepared will not be effectively engaged. Some will be bored, because the class is pitched below the level at which it is challenging, others will be left behind, because it will be too challenging. Personalization involves being able to design instruction so there are productive ways to support all students in learning. But this requires information about students' interests and abilities, ongoing information on their engagement and learning, and skill on the part of teachers to adjust instruction to these differences. In too many classes such personalization is not happening, either because classes are too large, because information on students' interests and abilities is lacking, or because teachers lack the skills to target instruction to students at different levels or to support students with different learning needs.

Those differences among students may extend to previous background knowledge, to command of the dominant language of instruction, to cultural background and familiarity with the cultural referents of the curriculum or to special learning needs or disabilities. Effective curriculum and instruction can meet students where they are in those dimensions, for instance tapping on cultural funds of knowledge to relate what is taught to topics which are familiar to students, or teaching in the language students speak at home or providing special support for students with special learning needs. However, as with differences with student interests and abilities, too many students experience an instruction which has not been designed for them. For instance, most students with special learning needs in the Global South are taught by teachers unprepared to support them effectively.

Given these shortcomings of the public education system it is not surprising that most existing studies of student learning conclude that students learn only a small fraction of the intended curriculum. These challenges are greater in poor countries and for poor students, and they have been termed the 'global learning crisis', discussed in Chap. 2. Drawing on the Carroll model of school learning we would conclude that such low levels of learning are largely a function of rigidities in education systems which prevent them from offering students the time they need to master content, in ways that students can comprehend, and a function of limited opportunities to check for students understanding and to provide them with feedback. In other words, the mass education systems that were built to provide access to school to all children, are unable to personalize learning in ways that allow all students to learn.

But the 'global learning crisis' focuses only on one of the intended goals of public education: the goal of delivering foundational learning to students. It underscores that even relative to the minimalist aspirations of Joseph Lancaster of teaching students the basics discussed in Chap. 1, public schools are failing many students. But what about a more expansive view of learning? How about students'

opportunities to develop a broader set of skills? To pursue their own interests? To reach their full potential by cultivating different interests and capacities, as Pestalozzi ambitioned? Evidence on this topic is less forthcoming, but what we know from international studies of student learning in science or civics is that the results are as limited as those in the foundational skills of literacy and mathematics.

In addition to the deficiencies students face to support them in gaining foundational skills, as well as an expanded set of skills which may equip them to meet the needs of a more demanding world and workplaces, such as science and civics, there is the question of what are students learning that would enable them to effectively deploy or develop artificial intelligence, or understand how it works and its shortcomings, what we might term AI literacy. The evidence on this topic is still very limited, but what is available suggests that the opportunities for students to gain the skills to engage with AI as a form of co-intelligence are scarce.

3.3 Can Artificial Intelligence Address These Shortcomings?

Artificial intelligence (AI) holds significant promise for addressing many of the chronic shortcomings of public education systems—particularly those stemming from a "one-size-fits-all" model that does not effectively support most children in heterogeneous classes. Adaptive learning platforms powered by AI can analyze students' responses, learning speeds, interests, and gaps in knowledge to dynamically tailor instruction, pacing, and feedback for each learner. AI platforms can also provide teachers with specialized knowledge to support students' particular learning needs (Bajpai, 2024; Martínez-Comesaña et al., 2023). They can also offer students opportunities to learn bypassing shortcomings of their own teachers in knowledge and skills, for instance teaching students to learn foreign languages even if their teachers are not qualified to offer foreign language instruction. It can also expand the curriculum available to students, allowing them to pursue individual interests. In theory, this level of personalization, unattainable for most teachers in large, heterogeneous classrooms, could support engagement, deepen understanding, and help ensure that fewer students are left behind or disengaged. For students with disabilities, AI can enhance access and participation through features like speech-to-text, automatic translation, and personalized content adaptation. In areas facing acute teacher shortages, AI applications can supplement human instruction, providing practice, formative assessment, and feedback where otherwise these would be missing.

AI-enabled tools can also support teachers by automating time-consuming administrative tasks, which would free up time for instruction as well as provide real-time analytics on student performance, and even suggest differentiated instructional strategies for diverse learning needs, all of which would support personalization (Anwar et al., 2023). Moreover, AI can help pull in culturally relevant examples, adapt content for different languages or learning contexts, and assist in the early identification of at-risk students so that interventions can be applied in a timely

manner. Collectively, these capabilities have the potential to narrow achievement gaps, increase equity, and better support the holistic development championed by educators like Pestalozzi. In what follows, we examine the evidence that pertains to uses of AI to support learners directly, whereas uses of AI to support teachers with instruction will be presented in Chap. 6. This distinction is clearly arbitrary, as students' direct uses of AI tools will typically be supported by teachers, in effect reflecting an instructional choice, no different than planning a lesson. However, we see some value in the distinction between the applications that are designed to interface with students directly and those that are designed to interface with teachers, constituting a form of job embedded professional development and support.

For student learning, technology plays multiple roles: it is an aspect of infrastructure requiring careful investment and maintenance; a means for delivering content, which must be contextually relevant; a basic skill in its own right, to be fostered at appropriate stages; and a planning tool, helping education systems gather and act on data about student learning and wellbeing. However, if technology is deployed without addressing underlying inequities—such as differences in access to electricity, connectivity, or devices—it may deepen the digital divide. For this reason, in contexts in which students do not have equal access to devices or connectivity, the most equitable uses of AI may not be student facing, but teacher facing. This is the concept of 'AI unplugged' developed by Professor Seiji Isotani, and illustrated with platforms in which teachers take pictures of student work, which is uploaded to an AI platform which uses a rubric to grade that work and provide feedback for teachers to follow up with students (Portela et al., 2025).

Concerns also arise regarding student privacy, safety, appropriate screen time, and the commercial motivations that sometimes drive ed-tech adoption.

In light of these considerations, efforts to harness AI and digital tools for student learning must be guided by foundational principles of inclusion, equity, and student agency. Technologies should be designed and evaluated to complement and enrich opportunities for learners, not to replace direct human engagement or to reinforce existing inequities. Policymakers and educators, therefore, have a responsibility to establish frameworks that safeguard learners' rights and ensure technology is always a tool for, and not a barrier to, educational opportunity and holistic development (Table 3.1).

3.4 What Does the Evidence Say?

Artificial intelligence is rapidly reshaping elementary and secondary education worldwide, offering new tools for personalizing learning, supporting teachers, and enhancing educational administration. However, its adoption is accompanied by complex challenges involving access, equity, teacher preparation and ethics.

Most studies conclude that AI's potential in elementary and secondary education is considerable but largely contingent on responsible implementation, educator upskilling, and thoughtful attention to ethics and equity (Crompton et al., 2022;

Table 3.1 Summarizes the challenges just discussed and the possible applications of AI to address them

Challenge	Possible AI solution
Inability of teacher centered instruction to accommodate different circumstances of students in terms of other demands on their time or need for support, for instance in terms of linguistic or cultural background	AI delivery of the curriculum would allow a shift from teacher centered instruction to student centered learning, allowing students to progress on their own time, at their own pace and with supports for linguistic and cultural characteristics of students
Limited opportunities for students to be taught at a level accessible to them, resulting from large heterogeneity of classes and from teacher centered instruction	AI personalized instruction would allow structuring fine grained learning sequences with period checks, adapting the sequence to level of understanding of students
Limited opportunities to check students understanding and to provide feedback based on that understanding	Student centered AI instruction allows ongoing assessment of student understanding, and adjustment of presentation of material and tasks to that understanding
Limited opportunities for students to develop higher order and transferable skills	AI delivery platforms, such as AI textbooks, can facilitate the exploration of cross curricular links, access to supplementary resources, access to an expanded curriculum in multiple subjects, and activities that focus on higher order skills such as collaboration, communication, creativity, etc.
Limited opportunities to develop AI literacy	Curriculum can develop AI knowledge and skills
Limited opportunities for students to learn based on their own interests	AI delivery platforms can expand opportunities for students to pursue their own interests in a range of subjects, including those not covered in the school curriculum

Majkić & Vranješ, 2024; da Silva et al., 2024; Melnyk, 2024). Research calls for further empirical studies to evaluate long-term impacts, best practices for teacher preparation, and strategies to mitigate bias and increase inclusion (Zafari et al., 2022; Chetry, 2024).

While the transformative potential of AI in education is widely discussed, current evidence is limited, nuanced and context-dependent. A recent review of the uses of AI in education in Latin America conducted by World Bank staff concludes:

> AI innovations in education are still in their early stages. While the potential for transformative impact is significant, there is currently a lack of rigorous evidence regarding their effectiveness and scalability in real-world contexts. To ensure responsible adoption and optimal outcomes, these innovations will require further evaluation and validation through carefully designed pilot studies and impact assessments. (Molina et al., 2024, p. 9)

While the review discussed the potential of AI to support students through AI-powered tutors who could personalize learning at scale, the limited studies cited evaluating tutors focused on higher education. No study in the review focused on elementary and secondary education.

An evaluation of the impact of Khan Academy—including online and offline resources such as practical exercises, instructional videos, and a self-paced learning dashboard—in Guatemala, concluded that students achieved significant learning gains in mathematics from using it (Fundación Sergio Paiz Andrade, 2016). It should be noted that the technology involved in this intervention, carried out almost a decade ago, was more basic than what AI makes possible today.

A recent impact evaluation of an after-school AI tutoring program for secondary students in Edo State, Nigeria, demonstrated that 6 weeks of participation in the program improved learning in an assessment including English, AI and digital skills. The gains obtained are equivalent to 1.5–2 years of learning in that system, with female students and those with higher levels of performance at the outset of the program exhibiting the largest gains (De Simone et al., 2025).

However, the impact of AI is likely heavily mediated by contextual variables, especially in the Global South. Challenges such as limited access to devices, unreliable internet connectivity, and gaps in teacher training can limit the scalability and effectiveness of AI interventions. Furthermore, there is limited rigorous evidence from low-resource settings or large-scale implementations. The use of AI in supporting non-cognitive skill development (like creativity or collaboration) and in fostering AI literacy itself is still an emerging area of research.

A recent systematic review of current research on the integration and effectiveness of AI literacy within K-12 school settings finds that most AI curricula and educational interventions are not yet embedded within standard school coursework but are instead offered as extracurricular programs such as after-school activities, camps, or elective programs. The reviewed interventions often employ active, hands-on methods—including project-based learning, game-based activities, and collaborative projects—to help students grasp complex AI topics and consider their societal impacts. The paper notes a shortage of teachers who are prepared and confident to teach about AI. Many interventions are constrained by the need for more comprehensive and systematic teacher training. While studies report positive short-term outcomes—such as increased AI concept comprehension, higher confidence, and better ethical reasoning—the review identifies a lack of research on the long-term sustainability of these gains and on the broader impacts, such as continued interest in AI courses or career choices (Lee & Kwon, 2024).

Teacher Preparedness and Perception: Teachers' perceptions are mixed—while some note benefits in efficiency and individualization, others perceive more limitations, including fears of inappropriate use, lack of critical review, and diminished teacher agency (Delgado et al., 2024).

Quality Assurance: Not all AI-generated content is of high educational value, and overreliance on generative AI may lead to superficial learning or teacher disengagement if not thoughtfully designed and accompanied by strong pedagogical frameworks (Matos et al., 2024).

3.4.1 Personalized and Adaptive Learning

A dominant theme in the literature is AI's capacity to support personalized learning pathways both in supporting learning the existing curriculum to personalize effective engaged learning time, as well as expanding the curriculum to support personal interests (Harry, 2023; Jara and Ochoa, 2020). AI-driven platforms and intelligent tutoring systems adapt content and instruction to each student's needs, allowing for self-paced and tailored experiences (Tapalova et al., 2022; Guan, 2023; Durães et al., 2024). Examples include machine learning-based recommendation engines that suggest appropriate practice problems, and virtual tutors that offer real-time feedback (Zafari et al., 2022; Hidayat et al., 2022). Studies report increased student motivation, engagement, and achievement when AI-based personalization is implemented (Tapalova et al., 2022).

3.4.1.1 Personalizing the Curriculum

AI platforms can personalize learning to write, providing feedback to students. Letrus in Brazil analyzes student-generated texts and provides feedback with respect to grammar, coherence, cohesion and style, offering recommendations for improvement. Petrus, also in Brazil, offers similar functionality (Rivas, 2025).

Integrating AI into classrooms also allows for continuous assessment and immediate feedback, further boosting personalization. For example, AI systems can identify knowledge gaps and suggest targeted interventions, which supports both students struggling with concepts and those ready for acceleration (Martin et al., 2023; Chetry, 2024).

A number of platforms support personalization across the curriculum. For example, Geekie in Brazil offers personalized assessment, generating personalized study lessons and drilling exercises (Rivas, 2025). Flex-Flix in Argentina provides on demand streaming of videos based on the national curriculum, supported by AI assistants that engage students in personalized interactions over the videos (Rivas, 2025).

KHistoriA is a platform to support learning history that allows students to engage in conversations with key historical figures (Rivas, 2025).

Plataforma AZ uses a generative text model to personalize the curriculum in a network of 400 schools in Brazil, offering personalized study plans, video classes, drills and immediate feedback (Rivas, 2025).

3.4.1.2 Personalization Expanding the Curriculum

AI enabled education platforms can expand the curriculum of instruction, for example supporting instruction of English as a foreign language in Latin America, offering opportunities for students to learn that language in spite of a shortage of qualified

teachers. Examples include TeeRead in Argentina, or Musiglota in Chile, or Leah in Colombia (Rivas, 2025). TeeRead engages students in reading and pronunciation exercises in actual conversations. Musiglota helps students learn English through lessons generated based on music that the user has on their device. Leah assesses the English language skills of users and generates a dashboard to monitor improvement.

Similar applications allow older students to learn coding independently, such as Escuela de Datos Viva in Argentina, a bootcamp to teach data science, or Platzi in Colombia, a platform of online courses using an AI assistant to help students develop a professional learning pathway and to personalize learning (Rivas, 2025).

In Colombia, Magnus learning teaches critical thinking skills through a catalogue of online courses supported by an AI assistant which can provide personalized learning pathways to students (Rivas, 2025).

In the United States, MATHia is a cognitive tutor, a widely adopted adaptive technology to support learning maths. It diagnoses the level of knowledge of students based on assessments, and uses students' errors as a base to understand their misconceptions providing them with elaborate automated feedback. The platform determines when students have achieved mastery of a topic and provides teachers with guidance for pedagogical moves that can help students. The platform also provides reports to teachers and administrators and planning resources. The platform is in use by more than 600,000 students and there is evidence that its use leads to improved learning outcomes in maths (Koedinger & Corbett, 2006; Fancsali et al, 2023; Pane et al., 2014; Ritter et al., 2007) in comparison to both paper-based and different interventions in ITS (OECD, 2021).

A similar adaptive learning technology in the Netherlands, Snappet, focused on Mathematics and Language in grades 1–6, assesses student knowledge on the basis of assessments, provides students with problems aligned to their level of understanding, provides feedback and then assesses learning growth. The platform determines when students are ready to proceed to a next level or content area based on their mastery of the curriculum. The platform provides teachers with dashboards that reflect progress and performance of students in the class, with information on their growth. The platform has been used in 2800 schools in the Netherlands (about 45% of all primary schools) and in 1000 schools in Spain. There is evidence that after 6 months of use students' knowledge of math increased (Faber et al., 2017; Molenaar & van Campen, 2016), and that knowledge of spelling increased marginally (Molenaar & van Campen, 2016), there are heterogeneous results over multiple years of implementation (Molenaar et al., 2017) in comparison to similar paper-based methods (OECD, 2021).

Of particular interest because of its accessibility in contexts without access to the internet is Beekee Box and Beekee Hub, a digital classroom that relies on a local wireless network, providing students access to a digital classroom, enabling interactive learning through digital content and assessments offline.

3.4.2 Supporting Diverse Learners and Inclusion

AI can enhance inclusion by providing accessible tools for students with disabilities or those who require individualized support (Santos et al., 2024). Intelligent tutoring systems and AI-powered accessibility tools such as screen readers or language translators facilitate participation for learners with varying abilities and backgrounds (Khazanchi & Khazanchi, 2021) (Table 3.2).

3.5 Conclusion

This chapter has examined the pivotal role of students and learning within education systems, exploring the promises and pitfalls of integrating artificial intelligence to support students directly—especially across the diverse contexts of the Global

Table 3.2 Summarizes the curriculum applications of AI in education with respect

Challenge	Possible AI solution
Inability of teacher centered instruction to accommodate different circumstances of students in terms of other demands on their time or need for support, for instance in terms of linguistic or cultural background.	Plataforma AZ in Brazil develops personalized learning plans. Intelligent tutoring systems and AI-powered accessibility tools such as screen readers or language translators facilitate participation for learners with varying abilities and backgrounds
Limited opportunities for students to be taught at a level accessible to them, resulting from large heterogeneity of classes and from teacher centered instruction	AI powered tutors are personalizing instruction adapting to the level of understanding of students, examples include KhanAmigo, Edo State Nigeria
Limited opportunities to check students understanding and to provide feedback based on that understanding	AI delivery of the curriculum providing feedback to students such as Petrus and Geeke in Brazil
Limited opportunities for students to develop higher order and transferable skills	AI delivery platforms, such as AI textbooks, can facilitate the exploration of cross curricular links, access to supplementary resources, such as Flex Flix in Argentina or KHistoria in Brazil. The following platforms support English learning TeeRead in Argentina, or Musiglota in Chile, or Leah in Colombia. Platforms to learn coding such as Escuela de Datos Viva in Argentina or Platzi in Colombia. Magnus focuses on Critical thinking skills.
Limited opportunities to develop AI literacy	Platforms to learn coding such as Escuela de Datos Viva in Argentina or Platzi in Colombia. We found few examples of this
Limited opportunities for students to learn based on their own interests	We found no examples of this

South. Subsequent chapters will examine the role of technology in curriculum design and delivery and in teacher preparation and support.

Drawing on a systems perspective and the three cross-cutting themes set out in Chap. 1, several key insights emerge for education policymakers, practitioners, and the wider education and technology communities.

3.5.1 Main Takeaways for Policy Makers and Practitioners

What is AI doing and not doing for students and learning?

3.5.1.1 AI Literacy

AI literacy is increasingly viewed as a core future competency; however, access to meaningful opportunities for developing AI literacy remains highly uneven. Most initiatives identified are targeted at urban or well-resourced contexts, and tend to focus on basic knowledge or coding skills rather than holistic understanding—encompassing ethical, societal, and creative dimensions of AI. As such, AI's contribution to building broad-based AI literacy is still limited and has not yet reached the scale or inclusivity needed for transformative change.

3.5.1.2 Foundational Literacies

There is compelling, though still nascent, evidence that AI-powered tools—like adaptive learning platforms and intelligent tutoring systems—can improve foundational skills such as literacy and numeracy, particularly where teacher shortages or lagging instructional quality persist. Nonetheless, most documented implementations remain at the pilot or early adoption stage, with significant disparity in access. The evidence to date suggests incremental innovations, but not broad, systemic transformation.

3.5.1.3 Twenty-First Century Skills and Relevance

AI has begun to support the acquisition of twenty-first century skills, including problem-solving, creativity, and collaboration—mostly through supplemental programs or project-based learning in select environments. However, large-scale integration into core curricula, particularly in under-resourced schools, remains rare. Current uses often focus on what is easily measurable, rather than the broader, more complex skillsets needed for future readiness.

3.5.1.4 Innovation vs. Transformation

AI's influence on student learning has been marked more by innovation—improving existing teaching methods or supplementing teacher capacity—than by complete transformation of educational models. System-wide paradigmatic change, where AI fundamentally reconfigures learning processes to be personalized, interdisciplinary, and equity-driven, is seldom observed. Where innovation does occur, it is often local, small-scale, and heavily dependent on favorable initial conditions (as highlighted in Chap. 1).

3.5.1.5 Equity and the Digital Divide

Importantly, there is mounting evidence that AI's educational benefits are accruing most to privileged groups—private or urban school students—with less reach among marginalized communities. There are risks of deepening existing inequalities due to uneven access to technology, varying digital competencies among teachers, and regional disparities in resources (Matos et al., 2024; Svoboda, 2024; Tambat, 2024). Without conscious policy intervention, this digital divide stands to deepen existing inequities, running counter to the promise of technology as a democratizing force.

3.5.1.6 A Systems Perspective

The evidence examined supports the systems insights introduced in Chap. 1:

- Initial Conditions: Infrastructure, teacher skills, and policy context significantly affect outcomes of AI adoption. AI integration requires supportive policies that address infrastructure gaps, teacher training, ethical usage, and ongoing evaluation. Teacher involvement in design, transparent algorithms, and community engagement are essential to build trust and ensure AI serves all students equitably (Vincent-Lancrin & Vlies, 2020; Guan, 2023).
- Interactive Effects and Synergies: Success occurs where AI is integrated with teacher support, curriculum reform, and ongoing feedback loops. Effective Small Changes, Big Effects: Even minor technological or pedagogical shifts, when aligned with system needs, can bring outsized benefits—but only when enabling conditions are met.
- Feedback Loops: Examples of continuous monitoring and iterative improvement through data-driven insights showcase early potential for systems-level learning. The systems perspective thus highlights the complex, often non-linear impact of AI in education, and underscores the necessity of holistic, integrated and coordinated approaches rather than piecemeal solutions.

3.5.2 Implications for AI Developers

For AI developers, the chapter reveals challenges and opportunities that remain unmet:

- Equity and Localization: There is a need for tools designed with low-resource environments in mind, with low connectivity and access to devices, supporting diverse languages, socio-cultural contexts, and learners with disabilities.
- Beyond Efficiency: Developers should move past narrowly focused, efficiency-based solutions toward co-creating tools with educators that support not only basic skills, but also critical thinking and broader learning outcomes. It is essential that AI tools are used to solve problems that students and teachers think they have, and not problems that developers imagine they should have.
- Enabling Transformation: Few tools fundamentally challenge or transform classroom practice or curriculum structure. Bridging the gap between innovation and system transformation will require deeper collaboration with teachers and policymakers, as well as openness to long-cycle, iterative development processes.

3.5.3 Ethical Questions and Concerns

Despite its promise, AI integration to support students directly brings several ethical challenges.

AI implementations raise significant concerns regarding data privacy, algorithmic bias, and accountability for automated decisions (Akgun & Greenhow, 2021; Weber, 2020; Chetry, 2024). As AI systems collect vast amounts of information about students, there is a risk that sensitive data could be misused, insufficiently protected or exploited, especially in weakly regulated environments.

Algorithmic bias is another key issue; if AI tools are trained on data that reflect historic inequalities, they may reinforce or even exacerbate educational disparities, providing less effective or even harmful recommendations for certain groups of students. When AI systems are trained on skewed or limited data, they risk reinforcing educational disparities rather than alleviating them.

There is an urgent need for frameworks and curriculum components that address ethical and societal implications of AI in schools (Akgun & Greenhow, 2021).

Transparency and explainability are also crucial. Students, teachers, and parents should understand how AI-driven decisions are made—especially in high-stakes settings like assessment or tracking. A lack of explainability for AI-driven decisions can erode trust and diminish student and teacher agency. Additionally, there are concerns about over-reliance on technology, potential deskilling of teachers, and the unintended consequences of automating core educational processes that require humanity, judgment, and cultural awareness.

Finally, questions of inclusion and equity loom large: if access to AI tools is uneven, the digital divide may widen existing educational inequalities rather than

narrow them. Unequal distribution of AI benefits further marginalizes already disadvantaged students, posing a threat to the core ethos of equitable education.

3.5.4 Emerging Research Questions

This chapter surfaces several questions that warrant further inquiry:

- Under what conditions do AI-powered learning tools improve student outcomes—particularly for the most disadvantaged learners?
- How can AI be leveraged to support not only foundational skills and cognitive development but also creativity, ethical reasoning, and other higher-order skills?
- What are the long-term impacts—both intended and unintended—of AI-enabled personalized learning on student motivation, self-regulation, social skills and educational equity?
- What are the best practices for effective integration of AI into existing classroom practices, and how can teachers be prepared and supported in this process?
- How do we ensure the responsible collection, use, and storage of student data in AI systems, safeguarding privacy and rights?
- How do different models of data governance, transparency, and accountability affect trust and acceptance among students, teachers, and families?
- What frameworks or safeguards are needed to detect and mitigate algorithmic bias in educational AI applications?
- How can AI be designed to promote cultural relevance, linguistic diversity, and inclusion for heterogeneous student populations in the Global South?
- To what extent does the introduction of AI in schools alter the role and professional identity of teachers, and how can professional development evolve accordingly?

In sum, this chapter reaffirms that while AI holds great promise for advancing student learning, realizing its transformational potential will require deliberate, equitable, and systemic action—addressing infrastructure, teacher capacity, curriculum reform, and robust ethical governance. Policymakers and AI developers alike must move beyond pilot-driven innovation toward approaches that strengthen the very fabric of equitable education systems, ensuring all students can thrive in a rapidly changing world.

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Chapter 4
AI and Curriculum

4.1 Introduction

From his wooden desk in a bustling Multan classroom in Punjab, Pakistan, Saad tries to follow along. His teacher is explaining a math concept on the chalkboard, her voice kind but her words moving too fast. Saad glances at the textbook, filled with problems that seem to be written in a different language. He sees other classmates nodding, their hands shooting up with answers, while he is still stuck on the first step. A feeling of panic mixes with shame; he tries to hide his blank page, hoping his teacher won't call on him.

A few rows ahead, his friend, Fatima, is doodling in her notebook, already finished with her work and bored. For her, the lesson is too slow, a repeat of what she already understands. Both Saad and Fatima are in the same classroom, following the same curriculum, but it feels like they are in different worlds. The curriculum, which is supposed to be a path for everyone to walk on, feels more like a tightrope for Saad, impossible to balance on, and a barricade for Fatima, holding her back.

This is the daily reality for millions of students. They sit in classrooms where a single, one-size-fits-all curriculum that emphasizes breadth over depth must somehow serve a vibrant mosaic of learners with vastly different needs and interests. Despite their teacher's best efforts to adapt her lessons, the sheer number of students, limited time, expansive content and lack of resources makes meeting every child's needs a herculean task. For too many like Saad, this mismatch leads to frustration and a feeling of being left behind; for others, like Fatima, it breeds disengagement. The curriculum, intended to be a great equalizer, often becomes an engine of inequality instead, rewarding those with strong foundations or significant support outside of school.

These students' and teacher's dilemma is the heart of this chapter, as we explore one of the most fundamental structures of any education system: the curriculum that guides what and when children are meant to learn. We will examine why this code so often fails to meet students where they are and ask how Artificial Intelligence is

F. Reimers et al., *Artificial Intelligence and Education in the Global South*,
https://doi.org/10.1007/978-3-032-11449-5_4

already being applied in an attempt to address these challenges, where it shows promise and where it has fallen short in creating a more personalized, equitable, and effective learning journey for all.

As Chap. 1 of this book explained, thinking systemically about education requires us to see not just the individual components of an education system—students, teachers, schools, policies—but the web of interactions that bind them together. One of the core supporting structures of this system is the curriculum, the structured progression of learning objectives and activities which guides teachers in supporting opportunities for students to learn. The interactions between the curriculum and other components of the education system, such as assessment, teacher capacity or instructional resources, are core to the provision of effective opportunities to learn.

We can think of the curriculum as a multi-layered construct. UNESCO (2023) characterizes it as the "DNA of the education system," a pivotal instruction code and instrument for educational quality. When this code is flawed, fragmented, or misaligned with other components of the system, such as teacher capacity, instructional resources or evaluation, there will be a gap between what is intended, what is implemented, and what is achieved in terms of student outcomes. These gaps define three layers of curriculum: the intended, the implemented and the achieved curriculum, a useful distinction formulated in the cross national studies of the International Association for the Evaluation of Educational Achievement, particularly in TIMMS (Mullis & Martin, 2013). Each layer is an enabling condition for the next, but does not determine it. That is, the intended curriculum makes possible the implemented curriculum, but more than intentions are needed for effective implementation. The implemented curriculum, in turn, makes possible the achieved curriculum, but does not determine it as more than teacher instruction shapes what students learn. These layers are further explored below.

- **Intended curriculum**: the formal goals, objectives, and content prescribed by educational authorities. There is wide variation across the world in how specific the intended curriculum is. In some systems the intended curriculum encompasses learning goals, in the form of standards, for the entirety of an education system and for each grade level and subject, leaving the development of a specific scope and sequence of activities up to teachers. In other systems, the intended curriculum includes the scope and sequence, sometimes in highly prescriptive ways that define not just what specific content teachers are expected to cover at each point in the academic year, but also how they should cover it and how students should be assessed.
- **Implemented curriculum**: what actually transpires in the classroom, shaped by teachers' interpretations, pedagogical choices, available resources, and the specific learning activities undertaken.
- **Achieved curriculum**: the tangible learning outcomes, skills, and competencies demonstrated by students as a result of their educational experiences.

4.1.1 Curriculum Challenges

We will explore three key areas discussed in the introductory chapter regarding curriculum and AI: first, what set of competencies, such as AI literacy and critical thinking, need to be developed within the curriculum. Second, can AI enabled tools support the implementation of curriculum in foundational literacies rather than undermine them. Third, can AI supports the development of an expanded set of skills and knowledge, what some call '21st century skills'. As we examine these key challenges and questions, we will return to the core tensions discussed in previous chapters. How can a curriculum designed for mass education contend with the vast student heterogeneity we explored in Chap. 3? How can it remain relevant in the face of the global learning crisis when it comes to foundational literacy, while there are rapidly evolving twenty-first century demands as detailed in Chap. 2? And how can AI be deployed not just to improve the efficiency of existing activities such as standardized curriculum development through substitution, but to transform what we do to align the curriculum with pedagogy, assessment, and the diverse needs of learners thereby improving outcomes? We begin with a discussion on what the current reality is in many classrooms in the Global South.

4.1.1.1 Knowledge—Based Curriculum, Foundational Skills and Transferable Skills

K-12 curricula in numerous Global South countries are frequently criticized for the lack of relevance to the local context, being excessively theoretical, and overloaded with content that prioritizes rote memorization over the development of essential twenty-first-century competencies (UNESCO, 2017). The traditional emphasis on broad content coverage, often at the expense of deep conceptual understanding, hinders the development of transferable skills necessary for lifelong learning and adaptability. There is often political and social pressure to offer a comprehensive curriculum, one that includes a wide array of subjects and contemporary topics. Two challenges emerge from an overcrowded and overambitious curriculum focused on the transmission of knowledge. The first, that it creates cognitive demands that exceed the zone of proximal development for most learners, resulting in students failing to master foundational skills. The second, that the focus on transmission of excessive content precludes the development of transferable skills.

The pressures to include too much in the curriculum frequently result in a curriculum that, while appearing robust and ambitious on paper, systematically fails a large proportion of students by moving too quickly and leaving many behind (Linden, 2017). The large number of students who spend several years in school and yet fail to read at the most foundational level, is what development agencies have termed the 'global learning crisis' or 'learning poverty', discussed in Chap. 2.

This challenge is compounded by the fact that, as demands for social and economic participation increase, students also need transferable skills. These

transferable skills, crucial for navigating an increasingly complex world, include critical thinking, problem-solving, creativity, communication, and collaboration to be college, career, and community ready, as outlined in frameworks such as the OECD Learning Compass 2030 (OECD, 2015) (National Research Council, 2012). Supporting the development of such an expanded range of competencies is the focus of ambitious national curriculum reform efforts in numerous countries (Reimers & Chung, 2016; Reimers, 2020). A common misconception is to see the development of foundational and transferable skills as opposites. This misconception stems from understanding that the limitations in instructional resources—instructional time, teacher capacity, resources, focus of the assessment—necessitate prioritizing one of these goals over the other. For instance, if we see the development of critical thinking skills or collaboration skills as something that requires dedicated time in the curriculum, such time is necessarily in competition with the time devoted to teaching foundational literacy or math. The challenge thus is to transcend this mindset of educational scarcity and replace it with one that sees the development of foundational and transferable skills as one and the same. For example, critical thinking and collaboration skills are developed not in a specific subject devoted to this, but across the curriculum, including in how students learn foundational literacy and math. It is evident that the capacity to see foundational and transferable skills as a 'both and' rather than 'either or' is not yet widely shared, this is an area where AI applications might help move from a mindset of scarcity in thinking about the uses of curriculum to one of abundance.

4.1.1.2 Challenges in Vertical and Horizontal Curriculum Coherence

Curriculum coherence encompasses two key dimensions.

1. Vertical coherence: the logical sequencing of content, skills, and concepts across different grade levels, ensuring that learning is structured in a logical progression that allows cumulative gains.
2. Horizontal coherence: the interconnectedness and integration of concepts and skills across different subject areas within the same grade level.

Effective coherence in both dimensions enables students to build upon prior knowledge, establish meaningful connections between different areas of learning, reduce cognitive overload by reinforcing key ideas across multiple contexts, and ultimately develop a more holistic understanding of the material (Schmidt & Prawat, 2006).

While vertical coherence within specific subjects, that is the coherence of what is taught across the curriculum in the same grade, might be attempted, it can be undermined by factors such as intended curriculum goals not achieved in various grades, high rates of teacher and student absenteeism, reduced instructional time, student repetition, and the lack of standardized learning benchmarks. Horizontal coherence, that is the coherence within subjects across grades, is often even more elusive with teacher evaluation and summative assessments conflicting with other parts of the system, such as curriculum materials or professional development, where knowledge is treated as a collection of disconnected facts (RAND, 2021). This often results in a curriculum that

is organized into strictly demarcated subject silos. While this structure may prepare students for subject-specific exams, it can limit their ability to make interdisciplinary connections, apply knowledge across different domains, and develop the kind of integrated thinking that is crucial for addressing complex real-world problems and the development of a more transferable understanding.

4.1.1.3 Addressing Learner Heterogeneity

We saw in Chap. 2 how the global learning crisis is characterized by millions of children who, despite being in school, are not mastering foundational skills. A key contributor to this crisis is the phenomenon of the overambitious curriculum. Political and social pressures often lead to curricula that are pitched far above the actual learning levels of most students. This creates a paradox: a curriculum that looks impressive on paper but that systematically fails the majority of learners, who fall behind early and never catch up. This directly links to the challenge of student heterogeneity examined in Chap. 3; a single, fast-paced curriculum cannot possibly serve a classroom where learning levels span multiple grades. Instead of being an equalizer, it becomes a powerful engine of inequality.

This fundamental mismatch between a uniform curriculum and the reality of extreme learner heterogeneity is a core driver of learning inequality in the Global South. This immense variation in preparedness means that a standardized, one-size-fits-all curriculum, delivered through whole-class instruction, will inevitably be mismatched to the needs of a large number of students. Those who are ahead may become bored and disengaged, while those who are behind struggle to keep up, fall further behind, and may drop out. As noted by Beatty and Pritchett (2012), when curricula are overambitious relative to actual student learning levels, many children effectively stop learning even if they remain in school, because the instruction is pitched too far above their current understanding.

4.1.1.4 Misalignment of Curriculum, Pedagogy, and Assessment Practices

Using systems thinking, for an education system to function effectively, there must be strong alignment between the curriculum (what students are expected to learn, the what), pedagogy (how teachers facilitate that learning, the how), and assessment (how student learning is measured and evaluated, the how well) (Hwa et al., 2020). Research indicates that when teachers use curriculum materials that are well-aligned with standards and pedagogical best practices, they are more likely to engage students in higher-order thinking and desired learning activities (EdReports, 2021). When these critical components are misaligned, students receive contradictory signals about what is important, teachers struggle to make informed instructional decisions, and it becomes exceedingly difficult to accurately measure learning progress or to improve teaching effectiveness.

A frequent case of incoherence in many Global South contexts is the relationship between curriculum goals and assessment practices. Even when curricula are reformed

to espouse competency-based learning, critical thinking, or learner-centered pedagogies, assessment systems—particularly high-stakes national examinations—often continue to prioritize the recall of factual knowledge through traditional testing formats (UNESCO, 2017). The nature of the examinations dictates classroom pedagogy and the implemented curriculum, regardless of the official curricular intent. Teachers may "teach to the test" which has been argued to not be an issue if the assessments are actually measuring desired outcomes, although this may hinder broader curricular goals or more innovative pedagogical approaches (UNESCO, 2017).

4.1.2 Reforms Addressing the Challenge of Lack of Alignment Between Curriculum and Context

For decades, reforms have sought to address the challenges mentioned previously, including calls for more learner-centered pedagogies, moving away from rote memorization to active and participatory learning (Schweisfurth, 2013). Competency-based approaches, focusing on what students can do with their knowledge have also been widely promoted. Strengthening foundational learning has been a perennial goal, alongside efforts to make curricula more locally relevant and culturally sensitive. Reforms have also often sought to enhance assessment practices to better measure a wider range of learning outcomes and provide more meaningful feedback. Differentiated instruction, which involves modifying curriculum content, instructional processes, learning products (how students demonstrate understanding), and the learning environment to meet individual student needs, is a widely advocated principle, such as through Universal Design for Learning (UDL). Despite these well-intentioned efforts, many ambitious reforms have struggled to achieve sustainable impact due to systemic challenges and the lack of systems coherence, perhaps reflecting low political will, resources, or limited data collection and implementation capacity, along with a wide range of other factors depending on the context.

As mentioned, the intended curriculum in many countries in the Global South is often disconnected from ground realities, reflecting national aspirations and global educational trends. However, its translation into practice is heavily mediated by a host of factors. An overemphasis on revising the formal curriculum document, without addressing the factors that shape its interpretation and implementation in diverse classroom settings, is a primary reason for the limited success of numerous curriculum reforms.

These factors include the processes of curriculum interpretation, the adoption by teachers, and the contextual realities of schools. These are just as critical as the curriculum document itself. Teacher capacity (including the knowledge of content teachers master as well as their pedagogical skills to teach such content) and training to implement the new curriculum, the availability and quality of learning resources such as shortage of teaching materials or outdated or misaligned textbooks, the physical and pedagogical conditions of classrooms including very large class sizes, the influence of assessment pressures (particularly high-stakes examinations), the support available to teachers to gain the knowledge necessary to teach the curriculum, the demands made on teachers and the time they leave available for

instruction, the readiness of students for the intended curriculum, and the sociocultural context of the school and community must all be considered (Asebiomo, 2015; Chirwa et al., 2022; Gurung et al., 2019; Ngwenya, 2020). A recurring pattern is one of producing curricula without providing teachers the necessary supports to develop the knowledge and pedagogical knowledge to implement it, as was the case with the implementation of outcomes-based education in South Africa in the 1990s (Jansen, 1998) and has recently been the case in curriculum reforms in Kenya (Fomiškina et al., 2021) and Zimbabwe (Gory et al., 2021).

Focusing on the intended curriculum without addressing the ecosystem that supports, or undermines, its implementation is a key reason why so many reforms have failed. Thus, curriculum reforms must adopt a systemic perspective, targeting not just the intended curriculum document but the entire enabling environment for its effective implementation.

4.2 AI and the Curriculum

How, then, could AI be used to address these deep-seated challenges? Technology, including AI, should not be viewed as a silver bullet or an isolated solution or a mere subject addition, but rather as one strand in the complex tapestry of curriculum transformation. AI's successful integration requires rethinking what counts as meaningful learning in fast-changing societies.

We must be cautious against overly narrow or unbalanced curricular strategies that may prioritize digital skills and content delivery at the expense of foundational literacies, social-emotional skills, ethics, and citizenship. Instead, curriculum must remain holistic—embracing the arts and humanities alongside science and technology, and foregrounding values of equity, empathy, critical thinking, and global citizenship. Particularly in the Global South, reforms must ensure that AI-driven curricular innovation does not exacerbate inequalities due to limited infrastructure, language barriers, or a mismatch with local traditions and realities (UNESCO, 2023).

Any technology-enabled curriculum reform requires continuous adaption, review and realignment to ensure coherence between intended policies, classroom implementation, and achieved student outcomes. This underscores the importance of ongoing teacher professional development, student voice, and robust feedback systems within curriculum change initiatives, so that emerging technologies and content remain relevant and beneficial for all learners (UNESCO, 2023).

4.2.1 Teaching About AI: Developing AI Literacy in the Curriculum

As nations recognize the importance of preparing students for an AI-driven world, a key challenge is determining what and how to teach about AI. UNESCO broadly categorizes AI curriculum content into nine topic areas, including algorithms, data

literacy, problem-solving, ethics, societal implications, and the application, understanding, and development of AI technologies (UNESCO, 2022). Such thematic concerns are reflected in the various approaches countries are taking to advance AI literacy. These approaches can be broadly categorized into two main themes: comprehensive, mandated national curricula and more flexible, programmatic initiatives.

What Is Being Done: Approaches to AI Literacy

Theme 1: Comprehensive, Mandated National Curricula

Some nations are pursuing a top-down, systemic approach, mandating AI education across all grade levels to ensure standardized, universal access for all students. This strategy aims to embed AI literacy as a core component of national education, signaling its importance for future economic and social development.

- **Evidence from China**: In a move to secure global AI leadership, China's Ministry of Education (2024) has mandated a comprehensive, tiered, and spiraling AI education curriculum for primary through senior high school, with a nationwide rollout in September 2025. The curriculum is designed to be age-appropriate, focusing on igniting interest at the primary level, building technical understanding in junior high, and shifting to systems thinking and innovation in senior high. Core competencies include AI literacy, critical thinking, human-AI collaboration, and social responsibility. Implementation involves transitioning from localized pilots to nationwide adoption, with AI education delivered either as a standalone subject or embedded within courses like science and Information Technology.
- **Evidence from the United Arab Emirates (UAE)**: The UAE has also taken a systemic approach, announcing the integration of AI as an official subject from kindergarten to Grade 12, beginning in the 2025–2026 academic year. The primary aims are to equip students with practical AI knowledge, foster tech ethics, and empower them to create locally relevant solutions. The curriculum features tailored units for distinct age groups, progressing from play-based discovery in kindergarten to advanced real-world application scenarios and prompt engineering in the senior cycle. Designated teachers will deliver the content within the Computing, Creative Design, and Innovation subjects, supported by comprehensive materials from the Ministry of Education and its partners.

Theme 2: Flexible Frameworks and Programmatic Initiatives

In contrast to mandated national curricula, other countries are adopting more flexible, often bottom-up approaches. These strategies may involve developing pedagogical frameworks, launching targeted programs, or running pilot initiatives that allow for greater local adaptation and experimentation before scaling up.

- **Evidence from Uruguay**: Uruguay's Plan Ceibal has developed a pedagogical framework to guide the integration of AI education, building upon its established Computational Thinking program. Rather than a rigid curriculum, the framework is structured around key questions (What is AI? How does it work? What

can it do?) and five core dimensions, including machine learning, computational problem-solving, and the ethical and social impact of AI. This approach emphasizes cultivating critical thinking, creativity, and an understanding of AI's societal implications (Arakelian et al., 2025; Ceibal, 2025).

- **Evidence from India**: India's approach includes national and state-level initiatives, with a key example being the YUVAi program for students in classes 8–12. This program focuses on fostering AI skills through project-based learning centered on real-world themes like AI in agriculture, healthcare, and education. This model empowers students to become human-centric designers and users of AI by applying their knowledge to solve tangible problems.
- **Evidence from Estonia**: Estonia has launched the AI Leap Initiative, a national program beginning with a pilot phase in September 2025. The initiative aims to enhance personalized learning and improve educational management by providing 20,000 students and 3000 teachers with access to AI-powered learning applications. This pilot-based approach allows for testing and refinement before a potential wider rollout, focusing initially on the practical application of AI tools in the classroom rather than a standalone AI curriculum.

4.2.2 Enhancing Teaching with AI: Addressing Curriculum Challenges Through Delivery and Design

What AI Could Do: Potential Roles in Curriculum Transformation
Beyond teaching about AI, there is immense potential to use AI as a tool to address the deep-seated curriculum challenges discussed earlier. AI could be not only a subject of study but a tool to support curriculum design and an engine for personalized delivery.

- **AI as a Curriculum Design and Content Partner**: For the challenges of overcrowded, misaligned, and irrelevant curricula, AI can act as a design partner. AI tools could help ministries and teachers adapt curricula by identifying and omitting non-essential content, generating supplementary materials tailored to local contexts and languages, and revising existing content to better align with student learning levels. This directly tackles the lack of local relevance.
- **AI as an Engine for Personalized Learning**: To address extreme learner heterogeneity, AI-enabled adaptive learning platforms can deliver personalized learning pathways. By moving beyond a one-size-fits-all model, these systems can provide developmentally-appropriate, scaffolded support at scale, allowing students to progress at their own pace and receive targeted help where they need it most.
- **AI as a System-Level Intelligence Hub**: To bridge the gap between the intended, implemented, and achieved curriculum, AI offers the potential for system-level analytics. By ethically aggregating and analyzing data on student performance,

AI-powered "intelligence hubs" could identify systemic learning gaps, create feedback loops for ministries, and inform continuous, evidence-based curriculum improvement.

What AI Is Doing: Thematic Applications in Practice

While the full transformative potential of AI has yet to be realized, initiatives across the Global South are already applying AI in these thematic areas, demonstrating its practical utility in curriculum design, content generation, personalization, and accessibility.

Theme 1: AI-Powered Curriculum Design and Material Generation

A significant burden for educators is the time required for lesson planning and creating engaging, culturally relevant materials. AI tools are emerging to automate and enhance this process, helping to overcome resource scarcity and improve the quality of the implemented curriculum.

- **Evidence in Lesson Planning and Content Creation:** In Brazil, Nova Escola's "Lesson Plans powered by AI" tool, accessible via WhatsApp, allows teachers to generate tailored lesson plans by interacting with an AI chatbot, significantly reducing their workload. Early results show over 15,000 users creating more than 63,000 lesson plans. Similarly, a World Bank-supported pilot in Peru trains teachers to use Microsoft Copilot to generate personalized activities and lesson plans in seconds, a task that previously took days. This trend is also seen with individual educators globally using general-purpose AI tools like ChatGPT to create differentiated worksheets, quizzes, and other materials (Microsoft, 2025).
- **Evidence in Developing Localized and Culturally Relevant Resources**: The GPE KIX STEPS project used AI to help draft high-quality, culturally relevant science textbooks for primary schools in Benin, Cameroon, and the Democratic Republic of Congo. In Mali, the RobotsMali initiative utilized AI to produce over 180 children's books in the local Bambara language in less than a year, addressing a critical shortage of mother-tongue reading materials. In South Korea, the planned 2025 rollout of AI-powered digital textbooks in core subjects aims to provide personalized learning experiences and reduce dependency on private tutoring (Cho, 2025), though it has been partially rolled back as of August 2025, because of pushback from teachers and parents over lack of teacher preparation, concerns over excessive screen time and data protection.

Theme 2: AI for Personalized Curriculum Delivery and Tutoring

Addressing the wide variation in student learning levels within a single classroom is a central challenge in the Global South. AI-powered platforms are being deployed to provide individualized instruction and support at a scale that would be impossible with traditional methods alone.

- **Evidence in Adaptive Learning Platforms**: In India, Mindspark is an established AI-powered adaptive learning tool for Mathematics and Hindi. It creates a customized learning journey for each child by breaking down concepts into micro-steps, providing immediate feedback, and dynamically adapting the difficulty of questions based on student performance. Similarly, Kolibri, an offline-

first platform used in over 220 countries, allows educators to align Open Educational Resources (OERs) with local curricula and deliver personalized learning pathways, making it highly effective in low-connectivity environments (Learning Equality, n.d.).

- **Evidence in AI-Powered Tutoring and Assistance**: A pilot program in Edo State, Nigeria, deployed Microsoft Copilot as a virtual tutor for secondary students, resulting in significant learning gains equivalent to 1.5–2 years of typical schooling (World Bank, 2025). The program was particularly beneficial for girls, highlighting its potential to bridge gender gaps. In Brazil, the Plu AI intelligent assistant, being rolled out to over 5000 schools, supports both teachers(by generating lesson plans and activities) and students by providing summaries, generating questions, and creating study plans (Índice, 2025).

Theme 3: AI for an Inclusive and Accessible Curriculum
AI is also being used to make curriculum content accessible to all learners, particularly those with disabilities or from linguistic minorities, thereby promoting equity in education.

- **Evidence in Translation and Accessibility Tools**: Researchers at Maseno University in Kenya have developed an AI-powered tool that translates English into Kenyan Sign Language (KSL), directly improving how Deaf students access and experience the curriculum. In Tanzania, there are plans to adapt Bookbot, a digital reading tutor that uses speech recognition, to the Kiswahili language, making it accessible to a wider population of young learners. These initiatives showcase AI's potential to break down long-standing barriers to learning.

Table 4.1 What AI could do

Category	Description
AI as a curriculum design & content partner	• Act as a design partner to ministries and teachers to adapt curricula • Generate supplementary materials tailored to local contexts and languages and revise existing content to better align with student learning levels • Map content to twenty-first-century skills and suggest interdisciplinary connections to create more coherent learning experiences
AI as an engine for personalized learning	• To address extreme learner heterogeneity, AI-enabled adaptive learning platforms can deliver personalized learning pathways • Provide developmentally appropriate, scaffolded support at scale, allowing students to progress at their own pace and receive targeted help where they need it most
AI as a system-level intelligence hub	• "Curriculum Intelligence Hubs" can ethically aggregate and analyze data on student performance to identify systemic learning gaps and create feedback loops for ministries • Transform data into a formative instrument for continuous, evidence-based curriculum • Improvement, identifying patterns (common misconceptions or struggling districts)

Table 4.2 What AI is doing

Category	Description	Examples/evidence from the chapter
AI-powered curriculum design & material generation	AI tools are being used to automate lesson planning and generate culturally relevant or localized educational resources	• Brazil: Nova Escola's tool via WhatsApp allows teachers to generate tailored lesson plans • Peru: A World Bank pilot trains teachers to use Microsoft Copilot to generate personalized activities and plan • Mali: RobotsMali produced over 180 children's books in the local Bambara language • Benin, Cameroon, DRC: The GPE KIX STEPS project used AI to draft culturally relevant science textbooks
AI for personalized curriculum delivery & tutoring	AI platforms are deployed to provide individualized instruction, adaptive learning, and virtual tutoring to address variations in student learning levels	• India: Mindspark provides adaptive learning for Math and Hindi, customizing the journey based on student performance • Nigeria: A pilot in Edo State used Microsoft Copilot as a virtual tutor, resulting in significant learning gains • Brazil: The Plu AI intelligent assistant supports students with summaries and study plans • Global: Kolibri delivers personalized learning pathways in offline/low-connectivity environments
AI for an inclusive & accessible curriculum	AI is used to translate content and make curricula accessible to learners with disabilities or those from linguistic minorities	• Kenya: Maseno University developed an AI tool to translate English into Kenyan Sign Language (KSL) for deaf students • Tanzania: Plans to adapt Bookbot, a digital reading tutor, to Kiswahili
Teaching about AI (AI literacy strategies)	Countries are implementing curricula to teach AI literacy, ranging from comprehensive national mandates to flexible, pilot-based frameworks	• China: Mandated, tiered AI curriculum from primary to senior high school focusing on AI literacy and critical thinking • UAE: AI integrated as an official subject from K-12 • Uruguay: A pedagogical framework based on computational thinking and ethical dimensions rather than a rigid curriculum • India: The YUVAi program focuses on project-based learning and AI skills for classes 8–12

4.3 Conclusions

This chapter has examined the role of AI in addressing curriculum challenges in the Global South. Looking through the lens of the book's central themes and informed by the systems perspective articulated in Chap. 1, several important conclusions emerge for policymakers, practitioners, and AI developers.

4.3.1 Main Takeaways for Education Policymakers and Practitioners

4.3.1.1 What Is AI Doing, and Not Doing, Within the Curriculum?

1. Development of AI Literacy:
   Progress is evident in the recognition that AI literacy is essential for all students, not just future engineers or computer scientists. Many curricula are beginning to shift to include foundational AI concepts, digital skills, and ethical awareness. However, access remains highly unequal, with efforts largely concentrated in a small number of better-resourced schools or education systems. In many low-resource environments, integrating AI literacy competes with urgent needs to address foundational skills gaps, and practical implementation is constrained by lack of training, resources, and local relevance.

   - **Holistic AI Literacy**: A number of countries have developed AI curricula. A promising trend is the shift away from purely technical AI education towards a broader, more holistic AI literacy. As seen in frameworks being developed globally, this approach rightly emphasizes ethics, societal impact, and critical thinking alongside technical skills. This is crucial for empowering students as critical citizens, capable of co-intelligence with AI and not just passive consumers of AI.
   - Cross-Curricular Integration: Rather than creating isolated AI subjects, integrating AI concepts across the existing curriculum appears to be a more pragmatic and scalable strategy. This method avoids overcrowding the curriculum and makes AI concepts more relatable by demonstrating their relevance in familiar subjects like social studies and science.
   - The examples we have examined suggest the possibility of developing context-specific AI tracks for different groups of students, a universal track that integrates AI students for all students, and a specialized track that offers secondary students opportunities to develop deeper AI skills, as is done in India and China.

2. Improving Foundational Literacies:
   AI-powered adaptive learning content and intelligent curriculum-support tools offer promise for addressing literacy and numeracy gaps. However, the

evidence reviewed suggests these innovations are often "bolted onto" existing over-ambitious or misaligned curricula, rather than catalyzing true alignment between curriculum, pedagogy, and assessment as envisioned in systemic reform. In practice, curriculum innovation is typically incremental, supporting foundational literacies for advantaged students but with limited reach in marginalized or rural contexts.

3. Improving Relevance for Twenty-First Century Skills:

   Some reforms embed competencies such as problem-solving, creativity, and collaboration alongside AI literacy, especially in pilot projects or elite institutions. Yet, as with foundational literacies, success is mostly local or project-bound. Most curricula remain content-overloaded and assessment-driven, with genuine interdisciplinary, competency-rich learning enabled by AI still rare at scale.

   We have not identified applications which support transformative views of curriculum, such as interdisciplinary curriculum or a curriculum in which individual students can pursue different interests. Although we have identified the following.

   - Localization of Content: Early case studies show a promising trend in using AI to adapt and translate curriculum into local languages and contexts. This directly addresses the challenge of resource scarcity and relevance, a long-standing issue in many Global South education systems.
   - Personalization for Heterogeneity: Adaptive learning platforms (like Mindspark and Plu AI) demonstrate a clear potential to address the significant challenge of learner heterogeneity in a single classroom by personalizing learning pathways.

     An implication of the evidence we have examined is the necessity to offer teachers sufficient and adequate professional development to be able to support AI literacy as well as to use AI applications. Teachers must be equipped with critical digital pedagogy to effectively integrate AI tools, understand their ethical implications, and use data to inform their practice.

     Two points of caution emerge from this review. The firsthand evidence is still very limited on the large-scale impact of the AI interventions, and as a result we know very little about their impact on students in the short or long term.

     It is also evident that the promise of AI tools cannot be fulfilled without addressing the infrastructure constraints of the Global South, including limited connectivity, lack of devices, and inconsistent electricity. AI initiatives must be designed with equity at their core to avoid increasing inequalities.

4.3.1.2 Innovation vs. Transformation

The emergence of AI in curriculum design exemplifies innovation, piecemeal improvements like personalized pacing or digital supplementation. However, system-wide transformation, where curriculum is truly reshaped to bridge

foundational skills and future competencies, remains rare. Where transformation begins to occur (such as in curriculum pilots integrating AI, teacher development, and authentic assessment), it is almost always underpinned by significant leadership, policy coherence, and resource investment.

4.3.1.3 Equity and Curriculum

The risk of widening divides persists. Most examples of curriculum innovation involving AI are urban, private, or high-income country cases; the marginalized majority is yet to benefit. Curriculum digitalization, if not contextually localized and supported, can exacerbate exclusion, leaving local languages, cultures, and diverse learner needs behind.

4.3.1.4 Systems Perspective

A systems approach reveals the interconnectedness of curriculum, teaching, and assessment:

- **Initial Conditions**: Curricular innovation's impact is shaped by teacher capacity, infrastructure, local policy priorities, and broader education system constraints.
- **Interactive Effects and Synergies**: Highest gains are seen where curriculum change is aligned with professional development, assessment reform, and community engagement.
- **Feedback Loops**: Data from digital curriculum tools can inform ongoing refinement, but is not yet systematically or equitably used for continuous improvement.
- **Role of Small Changes**: Small, context-sensitive shifts in curriculum design, when reinforced by aligned interventions, can catalyze outsized effects, but major, enduring impact depends on comprehensive system alignment.

4.3.2 Implications for AI Developers and Education Stakeholders

AI developers face both opportunity and responsibility:

- **Localization Is Essential**: Effective AI-enabled curriculum tools must reflect diverse languages, cultural contexts, and foundational classroom realities, especially where printed materials may remain dominant.
- **From Content Delivery to Competency Development**: Developers should shift from digitizing content to partnering with educators in co-creating curricula that enable critical thinking, collaboration, ethical reasoning, and adaptability.

- **True Transformation**: Current tools often digitize existing curricula rather than reimagining what, how, and why students learn. Deeper, systemic work is required for technology to become a catalyst for authentic transformation.
- **What's Missing**: Few existing solutions bridge the gap between digital and physical classrooms, support teacher-driven curriculum adaptation, or enable formative, ongoing curriculum evaluation across system levels.

The true transformative potential of AI lies not just in optimizing current practices but in creating entirely new capabilities for curriculum design and system improvement.

- **From Delivery Tool to Design Partner**: While current AI focuses on curriculum delivery, the next frontier is AI for curriculum design. The vast datasets collected by adaptive platforms on student performance, engagement, and misconceptions are a goldmine. This data can fuel AI tools that help ministries of education and curriculum developers:
  - Analyze existing curricula for gaps and misalignments.
  - Map content to twenty-first-century skills and learning standards.
  - Identify and suggest interdisciplinary connections, creating more coherent learning experiences.
- **Creating System-Level "Curriculum Intelligence Hubs"**: Imagine a future where anonymized data from various educational AI platforms is ethically aggregated at a district or national level. These "Curriculum Intelligence Hubs" would function as a nervous system for the education sector.
  - **Function**: Using AI-powered analytics, these hubs could identify systemic patterns in real-time, pinpointing common misconceptions, a struggling district, or the most effective learning pathways for specific subjects.
  - **Action**: This would create a powerful data feedback loop, providing actionable, evidence-based insights to curriculum developers, textbook publishers, and teacher training institutions. It transforms data from a simple monitoring tool into a formative instrument for continuous, system-wide improvement, directly addressing the gap between the intended and the achieved curriculum.

4.3.3 Ethical Questions and Concerns

While the potential benefits of AI in the K-12 curriculum are significant, it is crucial to acknowledge and mitigate the inherent risks, particularly in the Global South.

- **Overcrowding the Curriculum**: There's a real danger of simply further burdening an already crowded K-12 curriculum by adding AI literacy. Integration, rather than addition, should be the guiding principle.
- **Risk of Widening Existing Gaps**: If AI-driven curriculum initiatives primarily benefit well-resourced K-12 schools or students who already have digital access

and skills, they could exacerbate existing educational inequalities. Implementation strategies must prioritize equity, ensuring that marginalized students, rural schools, and those with disabilities are not left further behind. Foundational literacy, numeracy, and deeper learning must remain priorities, with AI explored as a tool to support these, rather than a distraction from them.

- **Bias and Lack of Contextual Relevance**: AI algorithms are trained on data, and if this data reflects existing societal biases, AI tools can perpetuate and even amplify these biases in educational content and assessments. Furthermore, AI tools developed in one cultural context may lack relevance or be inappropriate in others. Ensuring local adaptation, diverse data sets, and ongoing auditing for bias is essential. Failure to respect or embed local languages and knowledge can marginalize learners, amplify global homogenization, and erode educational relevance.
- **Data Privacy and Surveillance**: Digital curriculum tools often collect student data, sometimes without adequate safeguards or transparency.
- **Commercial Influence**: Over-reliance on vendor-provided AI curriculum elements risks biasing education toward commercial rather than societal or learner-centered ends.
- **Equity and Voice**: Without participatory development, curriculum reform driven by AI may silence educator, community, and student voices, undermining legitimacy and responsiveness.

4.3.4 Emerging Research Questions

Understandably, given the pace of AI development and application, much of the current evidence focuses on inputs and descriptions of AI tools rather than their long-term impact. The field urgently needs to explore the following outcome-oriented research questions.

The fundamental challenges outlined in this book, such as creating vertically and horizontally coherent curricula that are relevant and aligned with national goals, are problems of system-level design. However, the majority of current AI applications are tools for classroom-level delivery. While essential, these delivery tools are a patch on a systemic problem. They help manage the symptoms (e.g., learning gaps) but do not yet address the root cause (e.g., a curriculum that is poorly designed or misaligned with student needs).

- **On Using AI to Improve Curriculum (Teaching with AI)**:
  - What is the impact on students of learning with AI platforms on the achievement of the intended goals of the curriculum, higher order transferable skills and social and collaborative skills? What impact does it have on intellectual autonomy? What differences are there in the potential learning gains for different types of students? While adaptive platforms like Mindspark and gen-

erative AI tutors from the Edo State pilot show significant short-term learning gains, what are the long term effects on students? Do these tools foster independent, self-regulated learners who can engage in cognitive challenging tasks, or do they create a dependency where students struggle without AI-driven scaffolding? How does prolonged use affect student motivation, curiosity, and metacognitive skills?
  - What is the impact of AI tools that support instruction, such as those that allow teachers to generate lesson plans, or personalize instruction, or localized context on student outcomes? Initiatives like RobotsMali and the GPE KIX project demonstrate that AI can rapidly produce localized and culturally relevant materials (International Development Research Centre, 2025). The critical next question is: What is the measurable impact of these materials on student literacy, engagement, and learning outcomes compared to traditionally developed resources? How does interacting with culturally-attuned content affect a student's sense of identity and connection to their education?
  - If found to be effective, how can AI-driven curriculum initiatives be equitably scaled, adapted, and localized across diverse contexts in the Global South?
  - The Edo State pilot suggested that girls, who started behind, gained more from AI tutoring. Is this finding replicable at scale and across different subjects and cultural contexts? How effective are current AI curriculum tools for students with disabilities (beyond translation tools like the one at Maseno University), neurodivergent learners, and students from linguistic minorities? Are we measurably closing achievement gaps or inadvertently creating new forms of digital inequality?
  - How can feedback from students, teachers, and AI-enabled data be harnessed safely and meaningfully to inform iterative curriculum improvement?
  - The Nova Escola case shows teachers save 30–60 min on lesson planning, but a key question remains: How is this saved time reallocated? Does it consistently translate into higher-value activities like personalized student feedback, small-group instruction, and deeper pedagogical reflection, or is it absorbed by other administrative tasks? What is the demonstrable effect on the quality of the implemented curriculum?
  - Can AI tools effectively bridge the systemic gaps between the intended, implemented, and achieved curriculum? For instance, if an AI tool helps a teacher create a lesson plan aligned with competency-based goals, does that change in the implemented curriculum lead to better performance on assessments that measure those specific competencies, thereby shrinking the gap with the achieved curriculum?

- **On Curriculum about AI (Teaching about AI)**:
  - Assessing Authentic AI Competencies: National curricula in China, the UAE, and Uruguay aim to cultivate competencies like "human-AI collaboration skills," "critical thinking," and a "strong sense of tech ethics". How can these complex, non-technical skills be reliably assessed? What new forms of assessment are needed that go beyond multiple-choice questions and measure how

students apply ethical principles and critical thinking to real-world AI scenarios?
- Comparative Effectiveness of Curricular Models: What are the long-term outcomes of different national models for teaching about AI? For instance, does China's state-driven, comprehensive mandate produce different skills and ethical viewpoints compared to Uruguay's framework built on computational thinking or the UAE's integrated approach? Which models are most effective at preparing students not just for jobs, but for critical and engaged citizenship in an AI-shaped world?
- What governance mechanisms protect against commercial exploitation or bias in AI-driven curriculum platforms?
- How can teacher professional development and assessment support curricular reforms using AI?

In summary, this chapter demonstrates that integrating AI into curriculum offers promise for supporting relevant and timely learning, but evidence of transformation and impact on student outcomes, especially for the most disadvantaged learners, remains thin. Lasting, equitable impact demands that curriculum innovation be grounded in local context, aligned with systemic reforms, and developed in partnership with educators and communities. The lessons for stakeholders are clear: meaningful change will come not from isolated digital curriculum projects, but from integrated, systemwide efforts that position AI as one element in a broader, just, and responsive educational ecosystem.

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Chapter 5
Assessment and AI

5.1 Introduction: The View from Accra

A senior official at Ghana's Ministry of Education sits at her desk in Accra. Before her lie two documents: one that tells a story of aspiration, and another a story of inertia. The first is Ghana's ambitious new competency-based curriculum framework, a well put together printout filled with the language of transformation: critical thinking, collaboration, problem-solving. The second is a black-and-white spreadsheet detailing the latest national exam results. It tells a different story. The top-performing districts are, predictably, the ones most adept at drilling students for rote memorization, a practice the new curriculum was designed to leave behind. This scene, playing out in ministries across the Global South, encapsulates the tension of modern education reform: the chasm between what education systems *want* to measure and what their legacy assessment systems *can* measure, and indeed incentivize teaching in the classroom because what we measure, and how we measure it, becomes what matters.

This chapter argues that careful integration of AI presents an opportunity to resolve this paradox. It offers a pathway to shift from assessments that primarily serve accountability, what we call summative assessment, to those that actively drive and shape learning, a practice known as formative assessment. However, this is not a story of technological inevitability. Adopting the principle of open-minded agnosticism that guides this book, we will demonstrate that without deliberate, evidence-based, equity-focused design and governance, AI risks becoming a tool of unprecedented surveillance that deepens the very learning crisis it purports to solve. The central question is not *if* AI will change assessment, but *how* we can steer its development toward genuine educational transformation rather than mere efficiency gains in an industrial-era model.

The latest UNESCO (2023) Global Education Monitoring Report, offers vital guidance for education systems considering the integration of technology and AI in student assessment. It highlights that while digital and AI-driven assessments can

F. Reimers et al., *Artificial Intelligence and Education in the Global South*,
https://doi.org/10.1007/978-3-032-11449-5_5

increase efficiency, create new ways of monitoring learning, and even expand the reach of assessment to previously underserved learners, their impact is not guaranteed to be beneficial in all contexts.

A central lesson is that technology is not a shortcut to better assessment; its use must be grounded in a clear understanding of local realities. In many settings, uneven access to devices, internet connectivity, or digital skills may widen assessment gaps rather than reduce them. There is also the risk that reliance on automated scoring and algorithmic assessments could reinforce biases or marginalize aspects of learning, such as creativity, collaboration, social and emotional skills, that resist easy quantification (UNESCO, 2023).

Effective digital assessment must therefore strike a balance: harnessing the potential of AI and technology to improve the development and use of results from formative and summative assessment, while retaining the irreplaceable role of educators in interpreting results, supporting students, and safeguarding fairness and context. We must ensure there are robust frameworks to ensure data privacy, equity in access, and the ethical use of student assessment information.

Ultimately, integrating AI with assessments should be part of a broader, system-wide reform, aligned with curriculum and pedagogy, designed to support, rather than constrain, both students and teachers. Where technology is adopted, it should serve the goal of deeper, fairer, and more meaningful learning for all, not just more efficient scoring.

5.2 The Assessment Paradox: Problems, Context, and Challenges

The idea that assessment of students' knowledge and skills should play a role in the process of education, and in the governance of education systems, is relatively recent. Much more recent in fact than the acceptance of the idea that all children should be educated, formally adopted as a global commitment only in 1948 when education was included as one of the rights in the Universal Declaration of Human Rights. It was only in 1960 that a group of educators proposed that assessment of student knowledge and skills across various education systems could be used to identify educational practices and policies that were beneficial. The idea was proposed by Torsten Husen, a Swedish educator, and gave rise to the creation of the International Association for the Evaluation of Educational Achievement, the IEA. The first IEA study was conducted in 1960 assessing maths, reading and geography and science among 13 year olds in 12 countries. In the United States it was only in 1966 that a landmark study of the knowledge and skills of high school graduates, commissioned by the US Department of Education, focused on learning as a key outcome of interest to examine the impact of education and social policy. Another form of assessment emerged concurrently with the interest in assessing student learning outcomes, as part of the development of the field of curriculum

studies: formative assessment. This was assessment for the purpose of improving a curriculum, an idea separately introduced by Michael Schriven and Benjamin Bloom in the late 1960s.

In much of the Global South, however, much education policy relied on measures of access to education and progression as outcomes of interest until the late 1970s and 1980s. The incorporation of assessment of student knowledge as a policy tool was supported by international development agencies as part of programs of international development assistance in the 1980s. In the 1990s, a global education conference convened by the UN and development partners in Jomtien, Thailand, issued a declaration to signal a recommitment to education as a development priority that emphasized learning as a key education outcome. This provided the intellectual underpinning for the development of national assessment systems as a key education priority.

Different forms of assessment predate these formal efforts to assess student knowledge and skills as part of the process of educational improvement. They include the assessments that teachers and schools must make to decide how to promote students from one grade to the next, and to determine whether they have successfully completed a course of study. Those high stakes assessments, often depending on judgements made by teachers, were in many cases designed more to allocate scarce spaces available in an education level to aspirants completing the preceding level, rather than to inform the process of teaching and learning. In the same tradition are assessments of aptitudes and abilities used to select individuals for particular occupations, such as work in the military.

The practice of educational assessment in the Global South as a tool in the repertoire of educational improvement efforts is heavily shaped by capacity to carry out adequate assessments with tools of known psychometric properties, institutional culture, plus a host of other political pressures.

The Influence of Assessment on Instruction

Two characteristics of assessment of student knowledge are important constraints to educational improvement. The first is that across much of the Global South, particularly in former British colonies, the high-stakes examination used to determine which students have satisfactorily completed an education level, and are therefore ready to transition to the next level, is the sun around which the entire education system orbits. These tests, the Matriculation, O levels and A levels, administered at the end of primary, junior, or senior secondary school depending on the education system in question, function as the primary mechanism for accountability, student selection, and teacher evaluation. Their consequences are great, determining a student's progression to the next level of education, their eligibility for scholarships, and often, their life trajectory (Kellaghan & Greaney, 2001).

The second characteristic of assessment consequential for educational improvement is that many assessments in the global south focus on low order cognitive skills measuring short term recall because they are easier to measure.

These two factors, the high-stakes nature of assessments and the greater feasibility of assessing low order cognitive skills, create a powerful set of perverse

incentives. The most well-documented is the narrowing of the curriculum, a phenomenon where schools and teachers, under immense pressure to produce good results, focus exclusively on the content and formats likely to appear on the exam (Au, 2007). Subjects not on the test are neglected, and even within tested subjects, deeper conceptual understanding is sacrificed for the memorization of facts and procedures. This creates a fundamental misalignment between the intended curriculum, which may espouse twenty-first-century skills, and the implemented curriculum, which is dictated by the test (D'Angelo, 2021). The examination becomes the de facto curriculum, diluting the intent of ambitious reforms.

This dynamic reveals a critical systemic bottleneck. Even with a progressive curriculum as we discussed in Chap. 4, and well-supported teachers as will be discussed in Chap. 6, the system cannot transform as long as the ultimate measure of success remains a traditional, narrow examination. Traditional assessments struggle to provide timely, personalized feedback, to assess higher-order skills such as critical thinking, creativity, and collaboration (Swiecki et al., 2022; Hopfenbeck et al., 2023; Fan et al., 2023a, 2023b, 2023c), or to address diverse learner needs, exacerbating inequities and limiting opportunities for formative learning (Saal et al., 2025a, 2025b; Funda & Mbangeleli, 2024). The lack of teacher training in assessment design and interpretation further constrains the effective use of assessment for improvement purposes (González-Calatayud et al., 2021a, 2021b).

These examinations thereby often deepen the inequalities described in Chap. 2. They tend to penalize students from disadvantaged backgrounds, those in under-resourced rural schools, from low-income households, who speak a minority language at home, who have less access to the resources needed for intensive test preparation. Instead of being a neutral measure of merit, the high-stakes exam can become a tool for reproducing social stratification, laundering privilege into merit.

The Unfulfilled Promise of Formative Assessment

As mentioned, educational assessment emerged with a clear formative purpose, at least in some intellectual traditions. In this tradition of formative assessment, often called "assessment *for* learning", the process of assessment is not a single event but a continuous process of gathering evidence about student understanding to provide real-time feedback that modifies teaching and learning activities (UNESCO, n.d.-a, n.d.-b) When effective, it is one of the most powerful levers for improving student outcomes (Tao, 2025).

Yet, in the Global South, there is very limited use of assessment for formative purposes for structural reasons. In a classroom with 50, 60, or more students, assessing students frequently is a very difficult task (Van der Nest et al., 2018). To this we must add the challenges of limited teacher capacity, which will be discussed in Chap. 6, as a result of which teachers lack the sustained, practical professional development needed to master formative techniques. In addition, teachers are often overburdened with administrative duties (Rahman et al., 2021). Finally, in some systems, the entire school culture, driven by the high-stakes exams, is oriented toward summative accountability, leaving little room for assessments that are not graded (UNESCO, n.d.-a, n.d.-b). In some cases, the logic of summative assessment

has even co-opted formative practices, with scores from quizzes and classroom activities being used for promotion decisions, thereby stripping them of their low-stakes, diagnostic and potentially formative purpose (Tsuruta & Kuroda, 2021).

The Challenge of Assessing Twenty-First-Century and "Uniquely Human" Skills

Compounding these issues is a growing measurement crisis. As economies evolve, there is a global consensus that education must cultivate a broader set of transferable and uniquely human skills, competencies like collaboration, creativity, critical thinking, and communication that are resistant to automation. Yet, these complex skills are notoriously difficult to assess with traditional paper-and-pencil tests.

The assessment tools that do exist have largely been developed and validated in high-income contexts. They cannot be copy-pasted to another context there the language may be unfamiliar, the cultural references alien, and the technological requirements prohibitive (Ramírez-Casas-Del-Valle et al., 2023). A game-based assessment of problem-solving developed in the United States may be invalid in a rural Haitian school where students have not used a computer and are unfamiliar with the cultural storyline of the game. This creates a critical gap: education systems are being urged to teach skills they have no reliable, valid, or scalable way to measure, and then to mark.

5.3 Assessment Reimagined: What AI Could Do

While the current landscape is fraught with challenges, AI offers a set of capabilities that could, if steered correctly, fundamentally reshape the purpose and practice of assessment. This is not merely about improving existing practice, but about enabling paradigms of understanding and supporting student learning that were thought to only be available to the privileged few, not at scale (Table 5.1).

From Episodic to Continuous: The AI-Powered Formative Feedback Loop

Imagine a future where assessment is not a dreaded event but an ubiquitous, ongoing process embedded to support the learning process itself. AI-powered adaptive learning platforms and intelligent tutoring systems can provide students with a continuous stream of personalized, real-time feedback (Tao, 2025). As a student in India works through a math problem on a tablet, the AI can detect not just that the final answer is wrong, but *why* it is wrong, identifying the specific conceptual misunderstanding in the moment it occurs and offering a targeted hint or a different type of problem to address it (Gjermeni & Prodani, 2024). Such adaptive learning platforms could also offer more instruction to students on specific domains they have not yet mastered, while a student who masters a concept can move on to learning new skills, so that all students are optimally challenged. This transforms assessment from a summative judgment into a formative dialogue, directly overcoming the barriers of class size and teacher workload that have historically limited the reach of formative assessment.

Table 5.1 What AI could do

Key assessment challenges	Potential AI-driven opportunities and interventions
High-Stakes Exams Driving Rote Memorization and Narrowing the Curriculum	Shifting from Summative Accountability to Formative Learning: • AI-Powered Formative Feedback can be embedded into learning platforms to provide a continuous, real-time dialogue that modifies teaching and learning • AI-Powered Portfolio Assessment can analyze a student's entire body of work over time to generate a holistic profile of competencies, moving beyond a single exam score
Difficulty Assessing Complex Twenty-First-Century Skills (e.g., Collaboration, Creativity)	AI for Making Invisible Skills Visible: • AI-Analyzed Simulations or education platforms can assess collaboration by measuring individual contributions, communication patterns, and team dynamics in a game-based environment or using chat/transcript data • Creative Process Analysis allows AI to assess critical thinking by examining how a student interacts with generative tools—, analyzing their prompts, drafts, and idea iteration rather than just the final product
Lack of Timely, Personalized Feedback, Especially in Large Classes	AI for Personalized, Real-Time Feedback at Scale: • Intelligent Tutoring Systems (ITS) and adaptive platforms can detect not just *that* an answer is wrong, but *why* it is wrong, and offer targeted support in the moment it occurs
Imported Assessments that Lack Cultural and Linguistic Validity in the Global South	Culturally and Linguistically Adaptive AI Assessment: • Generative AI can create assessment items that are deeply embedded in local contexts and languages (e.g., using examples from local ecosystems to test biology concepts), making assessment fairer and more meaningful

Making the Invisible Visible: Assessing Complex Skills

AI's most transformative potential may lie in its ability to assess the complex, process-oriented skills that traditional tests cannot capture.

- Collaboration: In a simulated, game-based environment, or by analyzed chats and spoken transctipts, AI can analyze the dynamics of a student team working to solve a problem. It can go beyond a simple group grade to measure individual contributions, patterns of communication, turn-taking, and the use of inclusive language, providing a rich, evidence-based assessment of collaboration skills that was previously impossible to capture at scale (Andrews-Todd & Kerr, 2019).
- Creativity and Critical Thinking: Instead of just evaluating a final essay, an AI system could analyze the entire creative process. By examining a student's interaction with a generative AI tool, the prompts they craft, the drafts they discard, the sources they synthesize, it could assess their ability to iterate, refine ideas, and challenge assumptions. The focus shifts from the artifact to the thinking behind it.
- AI-Powered Portfolio Assessment: Moving beyond single-point-in-time scores, AI could analyze a student's entire body of work collected over months or years—essays, lab reports, code, artistic creations, and project contributions. By

identifying patterns and growth trajectories across this diverse portfolio, the AI could generate a holistic, multidimensional profile of a student's competencies, offering a far more meaningful picture of their capabilities than a single exam score ever could (Mafanga, 2024).

Assessment on Their Own Terms: Culturally and Linguistically Adaptive AI
Perhaps most crucially for the Global South, AI offers the potential to solve the validity crisis of imported assessments. Generative AI can be used to create assessment items that are not just translated, but are deeply culturally and contextually embedded. Imagine a science assessment in Ghana that uses examples from local ecosystems and traditional farming practices to test concepts of biology, or a history exam in Peru that draws on local oral traditions (Onyebuchi et al., 2025). By aligning with students' lived experiences, such assessments can more accurately measure their understanding of the core concepts, rather than their familiarity with a foreign cultural context, making assessment fairer and more meaningful.

Thus, AI offers the potential to support assessment by automating grading, generating adaptive tests, and providing real-time, personalized feedback (Owan et al., 2023a, 2023b; Fan et al., 2023a, 2023b, 2023c). Generative AI can create diverse, contextually relevant assessment items, simulate complex problem-solving scenarios, and support holistic evaluation of skills such as creativity, collaboration, and critical thinking (Mao et al., 2023; Owan et al., 2023a, 2023b). In the Global South, AI could help bridge resource gaps, support multilingual and inclusive assessment, and enable large-scale formative evaluation even in under-resourced settings (Saal et al., 2025a, 2025b). AI-driven analytics can also help identify at-risk students and inform targeted interventions (Borna et al., 2024; Cruz-Jesus et al., 2020). Looking ahead, AI could facilitate continuous, embedded assessment that aligns with the broader educational vision outlined in earlier chapters.

5.4 Assessment and AI in Practice: What AI Is Doing

The journey from imagination to implementation is underway, but the evidence reveals a field moving in two distinct directions: one focused on improving the old model, and another striving to create a new one (Table 5.2).

Improvement: Automating the Old Model
Much of the current application of AI in assessment focuses on making existing, often problematic, practices more efficient.

- **Automated Grading Systems**: AI tools are increasingly used to grade both multiple-choice and, with growing sophistication, open-ended written responses. The primary benefits are speed and consistency, which can significantly reduce teacher workload. Such uses are even possible in contexts in which access to the internet is irregular and students do not have access to computing devices. However, this is largely an act of improvement rather than transformation. It

Table 5.2 What AI is doing

Category	Description	Examples/evidence from the chapter
Automated Grading and Formative Assessment	Using AI to automate the scoring of student work and provide teachers with tools for formative assessment to identify learning gaps	• General: Countingwell for math formative assessments • Liberia: AI chatbot to help students prepare for WAEC exams • South Africa: EGRA AI project to assess early reading in African languages • Brazil: AIED Unplugged to grade handwritten essays
Adaptive and Personalized Testing	Employing algorithms to adjust the difficulty of assessment questions in real-time based on student performance, providing a more precise measure of ability	• Uruguay: SEA+ platform for personalized learning activities • Colombia: OE Saber platform for personalized university entrance exam practice • India: Mindspark's adaptive learning platform
AI-Powered Proctoring and Exam Integrity	Using AI with webcams and algorithms to monitor students during remote exams to detect potential cheating	• South Africa: Use of AI proctoring services in higher education
Assessing Twenty-First-Century Skills	Leveraging AI in game-based or simulated environments to measure complex competencies like collaboration and problem-solving	• Brazil: Icapiedu platform using gamified stories to identify bullying symptoms and develop socio-emotional skills

makes the traditional summative model faster but does not fundamentally change its nature or address its limitations in assessing complex, nuanced thinking.

Automated grading systems and AI-driven assessment tools are increasingly used to provide rapid, consistent evaluation of student work (González-Calatayud et al., 2021a, 2021b; Martínez-Comesaña et al., 2023). AI can analyze large datasets to predict student performance, identify at-risk students, and deliver insights to educators, enabling earlier interventions and data-driven decision-making (Durães et al., 2024; Martin, 2023). An example of an assistant for Math teachers is Countingwell, a tool that helps teachers conduct formative assessments and provide guidance to teachers on how to address learning gaps, including providing resources and plans for experiential learning. In mathematics education, robotics and "teachable agent" systems enable interactive learning and assessment, with positive impacts on conceptual understanding and skill acquisition (Hidayat et al., 2022). For example, OE Saber in Colombia is a platform that provides practice for high school students to take the university entrance examination, creating a personalized study pathway for each student (Rivas, 2025). In Uruguay, SEA+ assesses student knowledge and skills in Math, Language and Sciences, providing immediate feedback and personalized learning activities.

Another example comes from The Center for Integrated Solutions (CIS) that is developing an educational tool to enhance the learning experience of students preparing for the WAEC exams in Liberia. This tool is an AI-powered chatbot, leveraging the capabilities of specialised language learning models (LLMs) for each subject area within the WAEC curriculum. This chatbot will provide personalised, accessible, and effective learning support, uniquely tailored to the needs of each student (AI for Education, n.d.-a).

Or in South Africa with the EGRA AI project, AI models can be used to automatically assess children's early reading abilities (letter-sounds and word-reading) in African languages (AI for Education, n.d.-a).

- **AI-Powered Proctoring**: The rise of online learning has fueled the growth of AI proctoring services, which use webcams and algorithms to monitor students for signs of cheating during remote exams. This technology has seen adoption in higher education in countries like South Africa (Tamassia, 2020). While framed as a tool for academic integrity, AI proctoring powerfully reinforces the high-stakes, high-surveillance paradigm of traditional examinations. It raises profound ethical questions about student privacy and creates a potentially adversarial relationship between the student and the assessment system (Vloeberghs et al., 2022).

Transformation: Enabling a New Assessment Paradigm

Alongside these efficiency-driven applications, a more transformative paradigm is emerging, centered on personalization and adaptation.

- **Computerized Adaptive Testing (CAT)**: A significant step beyond traditional fixed-form tests, CAT uses algorithms to tailor the assessment to each student in real time. If a student answers a question correctly, the next one becomes harder; if they answer incorrectly, it becomes easier. This approach, along with its variant, Multistage Adaptive Testing (MSAT), allows for a much more precise and efficient measurement of a student's ability level, particularly for those at the highest and lowest ends of the performance spectrum who are poorly served by one-size-fits-all tests (J-PAL, 2019).
- **Intelligent Tutoring Systems (ITS)**: these are computer-based platforms that use AI to deliver individualized instruction and feedback to learners (Fang et al., 2019). They represent the integration of formative assessment and personalized instruction. These systems often leverage advanced algorithms to adapt instructional content and methods based on each student's interactions and progress, offering a personalized learning experience.

A close analysis of these adaptive learning platforms reveals a fundamental tension at the heart of designing AI for education in the Global South: the *infrastructure-pedagogy trade-off*. Eneza Education achieves remarkable scale and equity of access by using low-tech SMS, which works on the simplest feature phones without internet (UNESCO, n.d.-a, n.d.-b). However, this technological choice limits its pedagogical depth to basic quizzes. At the other end of the spectrum, Mindspark delivers a truly sophisticated, adaptive assessment that produces very large,

rigorously documented learning gains, but it requires computer labs and reliable connectivity, limiting its reach to more resourced settings. Kolibri attempts a middle path with its innovative offline-first model, making rich digital content accessible in disconnected environments, but it sacrifices the real-time, dynamic adaptivity of a fully online system (Oche & Aleyomi, 2024). This is not just a technical dilemma, it is a core policy choice. Every ministry, donor, and developer must decide whether to prioritize pedagogical power, which risks excluding the most marginalized, or to prioritize access, which may mean going with less capable tools.

A potential response to that conundrum may be found in the work of Artificial Intelligence in Education Unplugged (Isotani et al., 2023). This program allows the deployment of AI solutions in contexts in which there is no regular internet connectivity. Using a mobile app to capture images of students' handwritten essays, these images were uploaded to a central server when the internet was available. The server uses natural language processing to assess the essays based on a rubric. Based on this assessment teachers receive a dashboard designed to guide student feedback and support (Freitas et al., 2022; Patel et al., 2022; Isotani et al., 2023; Portela et al., 2023).

An impact evaluation of the application of Artificial Intelligence in Education Unplugged to teach writing to 164,545 students in 8238 schools in Brazil showed similar gains for students in rural and urban areas, underscoring the promise of this approach to not reproduce equity disparities (Portela et al., 2025).

Testing Twenty-First Century Skills

A combination of AI and gamification creates engaging environments for skill development. Teachers are using these platforms to:

- Promote Collaboration: AI-driven games often require students to work together in virtual environments to solve complex problems.
- Enhance Critical Thinking: These systems can present students with adaptive challenges and puzzles that require strategic thinking and analysis.
- Spur Creativity: Gamified scenarios can encourage innovative solutions and out-of-the-box thinking.

Though based in the United States, ACTNext developed a pilot version of a Game Based Assessment (Crisis in Space) designed to assess the collaborative problem solving and related socioemotional skills of middle school (ISCED-2) students. In this game, a pair of two test-takers is tasked with working together to troubleshoot a series of problems on a space station, with one of them in the role of an astronaut on the station and the other in mission control on the ground. By having the students collaborate in a cooperative game, Crisis in Space delivers an authentic and engaging experience and improves upon earlier attempts to measure collaboration via student-"agent" (chatbot) interaction. It uses a wide range of data types, including user interface-generated telemetry, audio recordings of student conversation, and test-taker eye-tracking data. ACTNext has implemented advanced machine learning technology such as natural language processing (NLP) to process these data and score instances of collaboration (Chopade et al., 2018; OECD, 2021). A

game-based assessment that leverages AI in this way is being developed to assess foundational literacy in Africa (AI for Education., n.d.-b).

AI can also help assess more complex students' needs. For example, in Brazil, Icapiedu offers a platform with gamified stories that help identify symptoms of bullying, which are then used by a team of support specialists that work with schools developing socioemotional skills and bullying prevention programs (Rivas, 2025).

In summary, empirical studies show AI-driven assessment tools are already improving accuracy, efficiency, and personalization in various contexts (Owan et al., 2023a, 2023b; Fan et al., 2023a, 2023b, 2023c; Almasri, 2024). In Nigeria, a human-centered AI framework provided actionable feedback for teachers in large-scale assessments (Uko et al., 2025). In South Africa, AI-powered grading systems are being piloted to reduce teacher workload and provide timely feedback, though concerns about empathy and data privacy remain (Twabu & Nakene-Mginqi, 2024; Ragolane & Patel, 2024). However, most research and implementation still focus on higher education and well-resourced environments, with limited evidence from primary and secondary schools in the Global South (Owan et al., 2023a, 2023b; Williams, 2023; Ofem & Chukwujama, 2024).

5.5 Conclusion Charting a Course for the Future of Assessment

This chapter has explored the complex role of AI in reshaping educational assessment, particularly in the context of the Global South. By examining the interplay between summative and formative assessment, and reflecting on the evidence and emerging practices, we draw several key conclusions for policymakers, practitioners, AI developers, and researchers through the lens of the book's three themes and the systems perspective introduced in Chap. 1.

5.5.1 Main Takeaways for Education Policymakers and Practitioners

5.5.1.1 What Is AI Doing—and Not Doing—in Educational Assessment?

1. Development of AI Literacy:
   There is a growing awareness of the need for students and educators to understand both the potential and the limits of AI-based assessment. Yet, few systems have explicitly integrated AI literacy into assessment practices. Most users, including teachers, interact with AI-driven scoring, analytics, or feedback with little understanding of underlying algorithms or their biases, limiting the development of critical digital and assessment literacy.
2. Improvement of System Effectiveness in Foundational Literacies:

AI-powered assessment platforms have great promise for providing rapid, individualized feedback, automating grading, and expanding the range of skills that can be assessed, including in reading, writing, and mathematics. This can enable more data-driven instruction and earlier interventions for struggling students. However, the impact has mostly been seen in well-resourced schools or as part of small-scale projects, and rarely leads to measurable, system-wide improvements in foundational learning, especially where infrastructure or capacity is lacking.

3. Improvement of Relevance by Assessing Twenty-First Century Skills:
   AI offers opportunities to assess more complex competencies (collaboration, critical thinking, creativity) that are difficult to capture with traditional tests. Some platforms use learning analytics or simulations to evaluate such skills in new ways. Yet, most national or high-stakes assessments remain focused on factual recall and basic skills, due to alignment with legacy curricula and examination systems. Thus, AI's potential to fundamentally shift assessment relevance is just beginning and unevenly realized.

5.5.1.2 Innovation vs. Transformation

The use of AI in assessment most often represents innovation: automating existing practices, streamlining feedback, or widening formative data collection. Truly transformative shifts, where assessment fundamentally moves from summative accountability toward authentic, formative, and holistic learning, are rare and often constrained by lack of coherence with curriculum and teaching practices.

5.5.1.3 Equity and the Digital Divide

AI-driven assessments risk amplifying existing divides, as access to such tools is typically concentrated in urban, private, or well-resourced school contexts. Marginalized students, those without regular internet access, or those with disabilities remain less likely to benefit, with the potential for increased exclusion if automated assessment is used for high-stakes decisions.

5.5.1.4 Systems Perspective

Initial Conditions: Effective AI-enabled assessment is highly sensitive to baseline infrastructure, teacher training, and clarity of learning goals.

Feedback Loops and Synergies: Where AI-generated data is actively used for ongoing instructional adjustment and informs curriculum design, early gains are seen, but these examples are scarce.

Unintended Consequences: Without deliberate integration and support, AI can reinforce problematic "teaching to the test" cultures, misalignment of assessments

and curriculum, and superficial engagement with twenty-first-century skills, demonstrating the interconnectedness and non-linearity of education systems described in Chap. 1.

5.5.2 Implications for AI Developers and Education Stakeholders

The next frontier of AI in assessment lies beyond simply providing better answers or more efficient grading. The true transformation will come from developing AI that facilitates *assessment as learning*. This could involve AI-enhanced metacognition that helps students analyze and reflect on their own thinking processes, prompting them with questions like, "I see you approached this problem in a new way. What led you to that strategy?" It could also involve tools that facilitate high-quality peer assessment and feedback at a scale impossible for a single teacher to manage. The ultimate goal is to build tools that cultivate metacognition, self-regulation, and intellectual curiosity—the uniquely human skills needed in the twenty-first century. This would need to be done in a way where AI tools are tailored to multilingual, low-resource, and special needs contexts.

AI developers have a unique opportunity, and responsibility, to support more equitable, meaningful, and transparent assessment systems with:

Human-Centered, Inclusive Design: Tools should be developed with diverse learners and teachers in mind, building in accommodation for local languages, disabilities, and low-connectivity environments.

Transparency and Explainability: Current tools too often function as black boxes. Developers must prioritize transparency, allowing educators and students to understand how scores are generated and to audit for fairness and bias.

Supporting Systemic Change: Moving beyond automating legacy assessments, developers should co-design tools that promote formative, holistic, and culturally responsive assessment models in partnership with educators and policymakers.

What's Lacking: Few platforms fully integrate formative feedback loops, align seamlessly with classroom practice, or empower teachers to adapt AI-driven assessments for local needs.

5.5.3 Ethical Concerns

1. Data Privacy and Security: AI assessment systems often collect sensitive learner data, sometimes without adequate protections or informed consent.
2. Algorithmic Bias and Fairness: Risk of encoding and amplifying societal biases is considerable, especially when assessment algorithms are not rigorously audited or contextualized.

3. Accountability and Human Oversight: Over-reliance on automated scoring or analytics can erode teacher, student, or parent agency, with errors in high-stakes settings sometimes going unchallenged.
4. Inclusion and Accessibility: There is a danger of excluding students with limited access to devices, poor connectivity, or those who learn differently if tools are not inclusively designed.

5.5.4 Emerging Research Questions

Given the nascent state of AI in educational assessment, the field is filled with more questions than answers. Moving forward responsibly requires a commitment to a rigorous, independent research agenda focused on the specific contexts of the Global South, especially in K-12 as most research is in higher education:

- Efficacy and Equity: How can formative, real-time feedback enabled by AI be embedded within routine classroom practice across diverse contexts? What are the long-term impacts of AI-based formative assessment on learning outcomes, teaching practices, student motivation, and system-level equity? Under what conditions do AI-powered assessment tools measurably improve learning outcomes, particularly for the most disadvantaged learners?
- Assessing Complex Skills: How can we validate that AI tools are accurately and fairly measuring complex competencies like collaboration and creativity across diverse cultural and linguistic contexts? What new psychometric models are needed to ensure these assessments are reliable?
- Trust Factor: How do students and teachers experience the interaction with AI assessment tools, and what factors foster or erode trust?
- Teacher-AI Co-intelligence: What mechanisms effectively integrate AI-driven and human-judged assessment to support deep, equitable learning improvement at scale? What models of professional development (Chap. 6) are most effective at preparing teachers to be critical consumers and collaborators with AI assessment data, rather than passive implementers of technology? How can teacher training and ethical frameworks be developed to support responsible AI use in assessment?
- Bias Detection and Mitigation: What are effective and low-cost methods for auditing educational AI tools for bias? Which policy and governance models ensure data security, audit algorithmic fairness, and maintain human oversight in AI assessment?
- Cost-Effectiveness and Scalability: What are the true total costs of ownership for different AI assessment models (e.g., SMS vs. computer lab vs. offline server)? What sustainable financing and governance models (Chap. 8) can support equitable scaling? How can AI-driven assessment be adapted for diverse, resource-constrained environments in the Global South?

Gaps, Misalignments, and the Road Ahead

The most significant gap in the field today is between the transformative potential of AI to create formative, empowering, and equitable assessment, and the current reality of most applications, which are focused on improving the efficiency of existing, often rote-based summative models. The challenges of assessment in the Global South are systemic, rooted in misaligned curricula, overburdened teachers, and deep-seated inequities. AI tools that are dropped into this complex system without acknowledging this reality are likely to fail or, worse, to amplify existing dysfunctions. The path forward requires a systemic approach, one where AI assessment tools are co-designed with local educators, carefully aligned with pedagogical goals, and governed by strong ethical principles that place the most vulnerable learners at the very center of their design. Evidence, not hype, must light the way.

In summary, AI brings the potential to revolutionize educational assessment, but evidence thus far mostly reflects incremental innovation and accentuates longstanding inequities when not embedded in coherent, system-wide reform efforts. Transformation will depend on policy, design, and research that foregrounds inclusion, transparency, ethical use, and the empowerment of teachers and learners within the assessment process itself.

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Chapter 6
AI and Teacher Development

6.1 Introduction

In a small, rural school a few hours' drive from Bihar, India, Sir Kumar pins a certificate to the classroom's worn corkboard. It's from a one-day professional development workshop he attended last month in the district capital. The paper, with its official seal, speaks of 21st-Century Pedagogies, but it feels worlds away from the reality of his classroom, where sixty-five young faces stare back at him, their learning levels spanning what must be three different grade levels. The workshop was a blur of lectures, leaving him with a stack of handouts but no practical tools to help the child in the back who can't yet read or the one in the front who is already bored. He feels the familiar weight of isolation, the sense that he is alone in the monumental task of turning a rigid national curriculum into meaningful learning for every single child. Sir Kumar's dilemma is not his alone. It is the lived reality for millions of teachers across the Global South, the dedicated professionals who serve as the true guides through education.

As we have just discussed in Chap. 4, the success of a curriculum in creating opportunities to learn depends not just on what is written on paper (the intended curriculum) but on what is implemented in the classroom. A curriculum, no matter how thoughtfully designed, is only a blueprint. Teachers are the primary agents through which the intended curriculum becomes the implemented and achieved curriculum. It follows, then, that the quality, motivation, and capacity of the teaching workforce is a significant school-level factor determining whether any improvement effort succeeds or fails. However, due to lack of sustained teacher support at scale, high demands placed on teachers, and how the role of teachers has been constructed, the implemented curriculum often does not reflect the intended curriculum. Curriculum goals may not always align with the knowledge and skills of teachers to implement them. Even when teachers carry the skills to implement a challenging curriculum, administrative tasks often take time from instruction, giving teachers little time to work with students and to collaborate with colleagues. In this chapter

F. Reimers et al., *Artificial Intelligence and Education in the Global South*,
https://doi.org/10.1007/978-3-032-11449-5_6

we focus on the challenges, and opportunities, facing teacher professional development and on the role AI can play in addressing them. We address also how teacher professional development can help teachers develop the necessary digital skills to integrate AI responsibly into instruction.

6.2 Teacher Professional Development Challenges

Developing teacher capacity is critical to improving the quality of education as educators are the most significant school-level factor impacting student learning (UNESCO, 2014; OECD, 2005). A discussion on the contributions of teachers to opportunities for students to learn must by begin defining what knowledge and skills are necessary to create such opportunities. A synthesis of research on this subject identifies the following knowledge and dispositions as critical:

- General pedagogical knowledge
- Subject-matter knowledge
- Pedagogical content knowledge
- Knowledge of student context and their families
- Repertoire of metaphors to bridge theory and practice
- External evaluation of learning
- Clinical training
- Strategies to create and sustain learning environments
- Knowledge, skills, and dispositions to work with students of diverse backgrounds
- Knowledge and attitudes that support social justice
- Knowledge and skills to use technology (Villegas-Reimers, 2003).

To understand how AI might help, we must first grasp the scale of the challenges. High-quality teaching is a complex craft, built on a deep foundation of knowledge and skills: mastery of the subject matter, a grasp of general pedagogy, an understanding of the local student context, and the ability to use technology wisely, among many other competencies. This expertise isn't acquired in a single training course; it develops over a career, through a continuum of support that includes quality initial preparation, effective induction for new teachers, and career-long opportunities for growth. (Villegas-Reimers, 2003). In much of the Global South, however, this continuum is fractured.

Ineffective Professional Development: Education systems across the world confront challenges in every step of the continuum of teacher professional development, including weak incentives to attract qualified candidates to the profession, deficient initial preparation, limited support for beginning candidates and ineffective ongoing professional development initiatives to improve education quality. The professionalization of teaching is essential to supporting students in developing the full breadth of capabilities necessary for civic and economic participation. This requires a continuum of support, including high-quality initial preparation, effective

induction, continuous professional development, collaborative professionalism, and recognition of teachers' expertise and leadership (UNESCO, 2021).

Shortages and Quality Gaps: In countries in the Global South, a primary concern is the severe shortage of qualified teachers, exacerbated by rising school enrollment rates that consistently outpace the availability of adequately trained educators. This shortage is compounded by significant variations in the quality of the existing teaching workforce, with many educators lacking formal college education or comprehensive pedagogical training. Even when teachers are present in classrooms, a substantial number may lack the essential pedagogical competencies and robust subject matter expertise necessary for effective instruction.

Overwhelming Classroom Realities: These shortcomings are consequential given the demanding realities of classroom instruction in many countries in the Global South, as discussed in Chap. 2. High student-to-teacher ratios, inadequate resources, and heavy administrative burdens are common (Conroy, 2021). Teachers often face immense learner heterogeneity—students from multiple linguistic backgrounds or with special needs, without the specialized training to support them. This often leads to a reliance on traditional, lecture-based pedagogies, not because of a lack of will, but a lack of bandwidth and support. In the absence of effective and relevant professional development teachers often reproduce the pedagogies they experienced as students with the result that traditional pedagogical practices tend to persist, limiting opportunities for more student-centered, interactive, and effective learning experiences.

Thus unequal access to quality teachers directly impacts student learning outcomes and perpetuates cycles of educational disadvantage or advantage. These multifaceted challenges create a need for innovative, scalable, and contextually relevant teacher professional development (TPD) solutions capable of addressing both the quantitative and qualitative dimensions of the issue. These needs pertain both to preparing teachers for effective foundational instruction as well as for instruction of more ambitious twenty first century skills.

Compounding these issues is the new imperative to develop AI literacy: teachers need to themselves gain AI literacy, and the pedagogical knowledge to develop AI literacy, to support their students, and to effectively deploy and use AI based tools to support instruction.

Recent global analyses highlight that teacher professional development (TPD) in the age of technology and AI is not only a technical challenge, but also a matter of equity, professional agency, and sustainable improvement across diverse education systems (UNESCO, 2023). TPD for technology integration must be accessible, context-sensitive, and continuous, not a one-off intervention. Effective models often blend online and face-to-face approaches, build on peer learning, and foster professional communities of practice. Examples include large-scale teacher WhatsApp groups, national digital teacher networks, and online courses that span basic digital skills to advanced pedagogies.

Equally important, TPD should promote teacher well-being and autonomy. Programs must respect professional judgment, foster collaboration rather than surveillance, and protect digital rights such as the right to disconnect. Civil society,

teacher unions, and teacher leaders play a role in ensuring that training responds to teacher-defined priorities, rather than technology-industry agendas.

Finally, professional development must be inclusive and future-oriented. This means ensuring that teachers in remote or resource-constrained settings are reached, and that training is tailored to diverse linguistic and cultural contexts. It also means preparing teachers not only to acquire digital and AI-related skills but to critically engage with the ethical and pedagogical implications of these tools. Teachers should be recognized as active partners in shaping the future of education technology, not passive recipients.

Overall, there is a need for more effective teacher professional development in the Global South with respect to preparing teachers to develop AI literacy among their students, enacting instruction that advances the intended goals of a foundational curriculum, and also equipping teachers to help students gain 21st-century skills.

Lack of Effective Support for These Challenges

The primary mechanism intended to support teachers in addressing this three pronged challenge, ongoing teacher PD, has often fallen short. Traditional, one-off workshops, disconnected from classroom realities, have proven largely ineffective at producing sustained changes in practice as shown by evaluations around the world. A synthesis of studies on various approaches to teacher development concludes that there is no robust evidence on their impact (Cordingley et al., 2015). In part, such lack of impact of professional development programs is because many of them are unrelated to the needs teachers have or to the challenges they face in their practice, and often there is poor alignment between such programs and the curriculum (Villegas-Reimers, 2003; Schwille et al., 2007). Effective teacher professional development programs are practical, focusing on teacher practice; many are job embedded, engaging teachers with colleagues in their own institutions over extended periods, providing sustained support through coaching and peer networks; they are subject-specific and aligned with the curriculum; and they promote active learning, where teachers can practice and refine new skills (Villegas-Reimers, 2003). In terms of their quality they are informed by evidence, focus on subject-specific and pedagogical content knowledge, focus on student outcomes, and offer a balance between teacher voice and system coherence. In terms of their design and implementation they rely on active and variable learning, offer collaborative learning experiences and provide opportunities for feedback and job-embedded learning. In terms of support and sustainability they are ongoing, are sufficiently resources and have supportive and engaged leadership (Campbell et al., 2017).

These challenges are summarized in Table 6.1, which also includes areas in which AI could help address these challenges, a topic we address in the next section. As we discuss various areas in which AI could help we first present the case for what AI based applications could potentially do and we provide examples of how AI applications are already being applied.

One of the domains which AI is addressing concerns the very first step in the continuum of teacher PD: attracting qualified candidates to the profession. In Chile

Table 6.1 Comparative overview of teacher PD challenges and opportunities

Key TPD challenges	Potential AI-driven opportunities/ interventions
Teacher shortages, quality variations, inadequate pre-service & in-service training, high workload, infrastructure gaps (connectivity, electricity), traditional pedagogies, challenges in teaching AI	• AI for personalized TPD (e.g., TheTeacher.AI, Twenty-First Century Teacher Educator GPT) • For lesson planning and resource adaptation (local curriculum integration) • AI-powered instructional coaching/teacher support (WhatsApp-based) • Automating administrative tasks
Large student populations, teacher quality variance, access to quality training in remote areas, workload from grading handwritten work, need for improved reading/ comprehension support	• Large-scale personalized learning (e.g., reading/ comprehension interventions) • AI-powered grading for handwritten/digitized answers (e.g., DeepGrade) • Creating differentiated learning materials
Integrating technology effectively, enhancing teacher competence with new tools, student-centred pedagogy	• AI for improving teacher capacity in lesson design • Personalized learning platforms • Translating course materials

the platform 'Quiero Ser Profe' developed by the organization Elige Educar, uses AI to support teacher recruitment and retention, as chatbots and human tutors provide personalized information and feedback to students interested in the teaching profession. A similar application was developed in Ecuador through the program 'Quiero Ser Maestro' (Rivas, 2025) Table 6.2 summarizes some of the actual applications of AI to teacher development.

6.3 How Could AI Help Teachers Develop More Effective Pedagogical Knowledge and Skills?

Following our discussion of what effective TPD entails, let us explore if AI can help support in realizing this. This section examines the potential for AI to transform TPD by making it more personalized, accessible, and aligned with evidence and principles of effectiveness. We will subsequently explore how AI is being used for everything from lesson planning to instructional coaching. But in line with this book's guiding principle of open-minded agnosticism, we will critically assess the evidence. Where does AI truly add value for teachers? And where does it risk becoming another ineffective, top-down intervention that fails to empower the very professionals it claims to serve?

Table 6.2 What AI is doing

Category	Description	Examples/evidence from the chapter
AI for Lesson Planning & Material Generation	Providing teachers with AI tools to create, adapt, and differentiate lesson plans and instructional resources, reducing workload and tailoring content	• Ghana: "21st Century Teacher Educator GPT" integrates national curriculum and local context • Chile: UmmiA platform for lesson planning and parent communication • Argentina: RDV.IA platform for content creation and assessments • Brazil: Large-scale platform supporting 300,000 teachers • General: Magic School AI creates automated lesson planning, diagnostic assessments, and gamified learning • General: Teachy supports non-English classrooms in the Global South
AI-Powered Instructional Coaching & Support	Using AI chatbots and other platforms to offer teachers on-demand professional development, concept clarification, and pedagogical support	• Sierra Leone: Teacher.AI chatbot on WhatsApp for PD and lesson planning support • Ghana: GPT-4-in-the-loop pilot providing rural teachers with an AI teaching assistant • Germany: TDSS (Teachers' Diagnostic Support System) provides real-time diagnostic data to inform instruction • Mali: RobotsMali, AI pilot offering instructional support to teachers
AI-Enabled Professional Learning Communities (PLCs)	AI platforms to facilitate collaboration, resource sharing, and focused pedagogical discussions among geographically dispersed educators	• Platforms like Disco and Playlab.ai for virtual communities of practice • Knowt's AI PLC Agenda Generator to streamline meeting logistics
AI for Teacher Recruitment & Retention	Employing AI-powered supports to prospective teachers and improving recruitment into the profession	• Chile: 'Quiero Ser Profe' platform by Elige Educar • Ecuador: 'Quiero Ser Maestro' program

AI-augmented TPD, with its capacity for personalized and scalable training modules, presents a promising alternative to the limitation of traditional models. It provides a potential avenue to upskill the existing workforce by targeting specific competency gaps, such as lesson planning support or concept clarification in real

time. Moreover, the high student-to-teacher ratios and workload reported by teachers means educators often lack the time for traditional, time-intensive professional development. For AI-driven TPD to be viable and effective in such contexts, it must be designed for micro-learning (i.e. delivering content in small, short chunks targeting a specific skill or concept), mobile-friendly formats, on-demand access, and immediate applicability. In addition, AI tools that can automate certain administrative tasks, thereby freeing up teacher time, could also create more space for engagement with professional learning opportunities.

AI could support pedagogical shifts by introducing new tools, such as those for generating differentiated learning materials. However, this transformative potential is contingent upon TPD programs that focus on the pedagogical integration of AI, rather than merely on the acquisition of technical skills, ensuring that AI is used to enhance teaching rather than simply to digitize existing practices. Training should focus on how AI can be used to help teachers to do better things in terms of pedagogy, improving content knowledge and building teacher-student relationships, not just how to do the same things they have been doing but faster, like creating rote quizzes and tests that may now be obsolete. Therefore, the imperative is not simply AI adoption, but a learner-centered approach to AI integration that builds teacher capacity in service of making progress on the goals of education as we have defined them, rather than aiming for automation that devalues these essential human roles.

6.3.1 Planning Lessons and Developing Differentiated Instructional Materials

For teachers burdened by a lack of time and resources, AI can be a powerful assistant, helping to generate initial drafts of lesson plans, create differentiated materials for diverse learners, and adapt content to be more engaging and culturally relevant. This directly tackles the overambitious curriculum and learner heterogeneity problems, as discussed in Chap. 4. Such support not only helps teachers address professional challenges in real time, it also offers opportunities for job embedded professional development.

With a dense national curriculum that may feel disconnected from their students' lives or be written in a language that is not their students' mother tongue, AI can act as a bridge. Teachers could use generative AI to adapt abstract curriculum content with culturally relevant examples, analogies, and case studies that resonate with their students' local context. Evidence from various contexts suggests that collaboration between teachers and AI can lead to more engaging and motivating lesson plans. Numerous AI tools, including ChatGPT, LessonPlanner, and Teachy, have demonstrated utility in assisting teachers with instructional design. For instance, Teachy specifically caters to non-English classrooms in the Global South that may not have one-to-one device setups.

Another tool is Magic School AI, a platform that supports automated lesson planning, diagnostic assessments, and adaptive, gamified learning. It has been piloted in a range of countries, with evaluations suggesting that it reduces teacher planning time and increases satisfaction, though evidence of improvements in student academic outcomes remains limited (Yudono & Widya, 2025). Importantly, studies consistently highlight that the system's outputs require careful teacher review and adaptation to local languages, curricula, and cultural contexts.

In Chile, UmmiA supports teachers in developing lesson plans and instructional resources, as well as streamlining tasks such as communication with parents, developing rubrics or assessments (Rivas, 2025). In Argentina, RDV.IA is a platform developed by a publisher of education materials to support the development of lesson plans, creation of content, assessments of student knowledge, and a dashboard to follow up individual student progress (Rivas, 2025). In Brazil, a large-scale AI platform supports 300,000 teachers with lesson planning, drills and assessments based on the national curriculum standards (Rivas, 2025). And in Germany, the Teachers' Diagnostic Support System (TDSS), developed at the University of Hohenheim in Stuttgart, enables teachers to collect and analyse data on student characteristics, instructional content, and learning progress in real time (OECD, 2021). TDSS helps teachers adjust their lessons in the moment and plan future classes, showing how learning data can also be used across different subjects and at the whole-school level.

However, successful integration depends on adequate teacher training and support. Teachers frequently report feeling unprepared or skeptical about using AI, highlighting a need for tailored professional development (Delgado et al., 2024; Svoboda Gouvea, 2024).

The "21st-Century Teacher Educator GPT" in Ghana exemplifies a context-specific tool that integrates the national teacher education curriculum, local contextual knowledge, and even bilingual (English and local Ghanaian languages) support. Teacher.AI in Sierra Leone leverages an AI chatbot accessible via WhatsApp to provide teachers in low-resource settings with professional development support, concept clarification, and assistance with lesson planning. AI can also be employed to rewrite existing content to make it more accessible for emerging readers or learners with specific needs. Tools like Diffit, Eduaide.Ai, and others can instantly generate differentiated versions of learning materials, like leveled reading passages, tiered assignments with varying complexity, and customized practice problems. This could allow teachers to provide appropriate challenges and support for students at different readiness levels within the same classroom, a task that would otherwise be prohibitively time-consuming. Another example is the RobotsMali initiative, which used AI to rapidly produce over 180 children's books in the local Bambara language, addressing a critical lack of relevant reading materials.

However, the effective use of AI for lesson planning is still resource intensive. Research indicates that obtaining high-quality, pedagogically sound outputs from AI often requires significant coaching and skill in formulating effective prompts. This suggests that TPD for AI-assisted lesson planning must focus on developing teachers' capacity to judge the outputs as well as gain pedagogical prompt

engineering skills, or the ability to query AI in a way that elicits outputs aligned with desired learning outcomes, differentiation strategies, and contextual relevance. This is a new form of literacy for educators, moving beyond generic interaction with AI to a more targeted and pedagogically informed engagement. Teachers must have the pedagogical judgment then to be able to evaluate the outputs to ensure AI is being used to augment pedagogy with teachers in the loop.

The journey of developing such localized AI tools is not without its obstacles. A recent pilot project in Ghana explored the use of a GPT-4-in-the-loop system to support teachers. This initiative, referred to as the Ghana GPT program, provided 11 rural primary school teachers with tablets and access to a GPT-4 powered chatbot. The system was designed to act as a teaching assistant, helping educators with lesson planning, creating teaching materials, and finding new pedagogical strategies. The study found that teachers used the AI assistant for a wide range of professional tasks and reported that it helped them create more engaging, student-centered lessons (Nyaaba, 2025). However, the GPT produced hallucinations in underrepresented local languages due to the limited availability of digital corpora in those languages, highlighting a challenge for creating truly localized and linguistically diverse AI solutions (Nyaaba, 2025).

Thus, AI is not a magic bullet for lesson planning. Simply using an AI tool to generate a plan provides little value if the teacher lacks the pedagogical judgment to evaluate and adapt the output. The tool can even be detrimental if it produces factually incorrect, biased, or pedagogically unsound materials that an untrained teacher might use. The real value lies in the synergy between the teacher's judgement and the AI's generative capacity.

6.3.2 Instructional Coaching

One of the most effective but least scalable forms of TPD is individualized instructional coaching. AI offers the potential to provide personalized feedback at scale, helping teachers reflect on and improve their practice. These tools can analyze classroom recordings (audio or video) to provide feedback on teaching practices, offer automated, personalized coaching on specific aspects of teacher language (such as fostering a growth mindset), and support instructional leaders in analyzing their own coaching dialogues. AI can also assist teachers in self-reflection and goal setting (Li et al., 2024). This is particularly relevant in resource-constrained contexts, where access to human instructional coaches is often limited.

For example, Sierra Leone has piloted the use of chatbots to provide coaching support to teachers, developed through a collaboration between the Ministry of Basic and Senior Secondary Education, Fab Data, and others (AI for Education, 2024). These chatbots offer teachers low-cost, accessible feedback and guidance directly through their phones, making coaching support available even in rural areas where human instructional coaches are scarce.

We emphasize that for AI-driven instructional coaching to be genuinely effective in schools and education systems in the Global South, the feedback generated must be practical, pedagogically sound, and contextually relevant. Generic feedback from AI models trained predominantly on classroom norms and discourse patterns from different contexts, or on non-evidence based methods like the concept of learning styles, may not be applicable or could be counterproductive. This necessitates the development of well-trained AI coaching models using data from, and in collaboration with, educators in local classrooms, ensuring that the advice provided is appropriate and actionable. The *glocalization* of such tools, similar to the approach taken with the Ghana GPT (Nyaaba, 2025), is crucial.

The capacity of AI to analyze classroom dialogue holds the potential to provide more frequent feedback compared to infrequent human observations. Such systems could provide teachers with more regular, data-driven feedback on their questioning techniques, student engagement patterns, and overall dialogic quality. However, as we will explore in Chap. 7, ensuring school leadership is still the one to deliver that feedback to teachers may be important in terms of what we know about school culture, the sense that teachers are cared about, and are invested in. If AI coaching is perceived by teachers as a punitive surveillance tool rather than a supportive developmental one, it will be rejected. Trust is paramount. Without careful design that respects teacher privacy and focuses on supportive, actionable advice delivered within a culture of trust ideally by a human school leader, these tools will fail. Thus, training school leaders on how to provide feedback using that data may be a more conducive approach, which the next chapter will detail.

The widespread implementation of such systems faces significant hurdles, including skepticism that it will be used for teacher accountability, the need for appropriate recording equipment, reliable connectivity for data processing (unless designed for offline analysis), robust data privacy and security measures to protect both teachers and students, and clear ethical guidelines for the use of such data. Addressing these infrastructural and ethical prerequisites is essential before the full benefits of AI-supported dialogue analysis can be realized.

6.3.3 Simulations

AI-powered simulations can create a practice space for teaching and make training more practical. This involves interactive, dialogue-based virtual classrooms where a teacher can engage with AI student avatars. These avatars can be programmed with specific personas, common subject-matter misconceptions, and diverse learner profiles (e.g., a hesitant student, an overconfident one, a multilingual learner struggling with academic vocabulary). A teacher can attempt a difficult explanation, try a new questioning technique, or manage a simulated behavioral issue. Unlike in a live classroom, the scenario can be paused, replayed, and analyzed with detailed feedback without any risk to actual students.

We are seeing the development of tools like the AI-based Classroom Teaching Simulator (ACTS) being developed to help educators practice research-based instructional strategies in content-specific scenarios. A study in Poland that used a VR-AI-assisted simulation for pre-service English teachers found it to be highly valuable for fostering professional development and reflective practice regarding content knowledge application.

6.3.4 Deconstructing Expertise with AI: Making Masterful Teaching Visible

Novice teachers often struggle because the decision-making processes of expert educators are largely intuitive and implicit. It is difficult to learn what one cannot see. An innovative AI application can make this tacit knowledge visible by deconstructing masterful teaching. This involves using an AI tool to analyze video or audio recordings of highly effective local teachers. Using multimodal analysis, combining transcription of dialogue, analysis of tone of voice, and even gesture recognition, the AI can automatically identify, tag, and annotate key pedagogical moves.

For example, the AI could highlight a moment in a video and tag it as: "Effective Wait Time: Teacher paused for 7 seconds after a complex question, allowing students time to think," or "Scaffolding: Teacher broke down the multi-step problem after noticing student confusion."

This provides a scalable and on-demand alternative to the valuable but resource-intensive practice of having a human coach present for every classroom observation. The effectiveness of using video recordings in TPD is well-documented, and this AI application could supercharge the process.

6.3.5 Deepening Teacher Content Knowledge

A persistent challenge, particularly at the secondary level, is that teachers themselves may have gaps in their subject matter knowledge or struggle to articulate complex concepts clearly. To address this, an AI tool can be designed to function not as an information provider, but as a Socratic Sparring Partner. A high school chemistry teacher in Pakistan, for instance, preparing to teach stoichiometry, could engage this AI in a deep dialogue. The AI would not simply provide definitions; it would ask probing questions: "How would you explain the concept of a mole using a local, culturally relevant analogy?", "What is the most common mistake students make when balancing this type of equation?", "A student asks you why this concept is important for their daily life. What is your response?".

The goal shifts from getting an answer to being forced to construct and defend a teacher's, or student's, own understanding. This process could help teachers anticipate difficult student questions, identify weaknesses in their own explanations, and deepen their conceptual mastery. While the conversational capability of AI is well-established, this use case leverages it for a specific pedagogical purpose: to push the teacher's own thinking and build the robust content knowledge needed for high-quality instruction.

6.3.6 Summary

These potential applications of AI are all inherently interactive. They require the teacher to do something: to teach the avatar, to reason with the Socratic partner, to analyze the expert video. This transforms TPD from a passive event one attends into a continuous, on-demand cycle of practice, reflection, and refinement. Consequently, the role of the human coach or mentor evolves. They are no longer just deliverers of content; they become facilitators of reflection on these AI-mediated practice sessions, a potentially more scalable model.

However, building such sophisticated tools requires a new developmental framework. The well-known TPACK (Technological Pedagogical Content Knowledge) framework (Mishra & Koehler, 2009), and its successor AIPACK (Artificial Intelligence Pedagogical Content Knowledge) (Sezen-Gultekin, 2024), describe the knowledge a teacher needs to integrate technology. But for these tools to function, the AI itself must be imbued with Pedagogical-Content Knowledge. The student avatar must "know" common physics misconceptions prevalent in the Nigerian curriculum. The Socratic partner must "know" how to ask pedagogically powerful questions about Pakistani history. This requires a new form of expertise we might call Pedagogical AI Content Knowledge (PACK). Creating this capacity with AI tools necessitates a deep collaboration between AI engineers, subject matter experts, and, most importantly, local master teachers who can provide the nuanced, context-specific training data. A successful program must therefore invest not just in technology, but in building the human-led, interdisciplinary teams capable of "glocalizing" these AI tools for each unique educational context (Table 6.3).

6.4 How Could AI Help Teachers with Administrative Tasks?

One of the most discussed potentials of AI in education is its capacity to alleviate the often overwhelming workload faced by teachers, particularly in the Global South where administrative support may be scarce. By automating routine tasks, AI can free up valuable teacher time, enabling educators to focus more on direct student interaction, pedagogical development, and their own professional growth. Whether these are domains to which AI applications are targeted is to be determined.

Table 6.3 A developmental framework to use AI to support teacher professional development

	TPACK	AIPACK	PACK (Proposed)
Core Focus	The knowledge required by the teacher	The knowledge required by the teacher, with a specific focus on AI	The knowledge that must be embedded within the AI tool itself
Description	A framework describing the combination of knowledge a teacher needs to effectively integrate technology into their teaching. It involves understanding the interplay between technology, pedagogy (how to teach), and content (what is being taught)	A successor to TPACK, this framework specifies the knowledge a teacher needs to effectively and ethically use Artificial Intelligence tools to support their pedagogical and content-related goals	A proposed new framework arguing that for AI tools (like simulations or Socratic partners) to be truly effective, the AI itself must be imbued with pedagogical knowledge and content expertise relevant to the local curriculum and context
Key Question	What does a teacher need to know to use technology effectively?	What does a teacher need to know to use AI effectively?	What does an AI tool need to "know" to be an effective educational partner?
Example	A history teacher knows how to use a digital timeline tool (Technology) to help students understand chronological events (Content) through a collaborative inquiry-based project (Pedagogy)	A science teacher knows how to use an AI-powered formative assessment tool (AI Technology) to identify and address student misconceptions (Content) in real-time during a lab activity (Pedagogy)	An AI tutoring chatbot for physics is designed with knowledge of common student misconceptions in Nigeria (Content) and uses Socratic questioning techniques (Pedagogy) to guide students to the correct understanding. The knowledge is in the tool, not just the teacher using it

These tasks include managing attendance records, drafting basic communications to parents, grading certain types of assignments, generating initial drafts of reports, and organizing learning resources.

The promise of workload reduction through AI comes with important caveats. The AI tools themselves must not become an additional source of burden due to their complexity, unreliability, or the lack of adequate technical support. If an AI-powered attendance system, for example, is difficult to operate, frequently malfunctions, or requires extensive troubleshooting in a school with limited IT expertise, it could paradoxically increase teacher workload rather than decrease it. Therefore, simplicity, robustness, and user-friendliness are critical design considerations for AI tools intended for administrative automation in these settings.

Furthermore, there is a potential risk that the time saved by AI-driven automation might inadvertently be reallocated to new AI-related tasks rather than instruction if not managed strategically. For instance, teachers might find themselves spending considerable time on complex prompt engineering to get usable outputs from generative AI, meticulously verifying AI-generated content for accuracy and bias, or

manually inputting data into various AI systems. Educational policies and school-level implementation plans should therefore aim to ensure a net reduction in overall teacher workload, specifically safeguarding time for enhanced pedagogical engagement and professional reflection, rather than simply shifting the nature of the tasks.

6.5 Enabled Professional Learning Communities

A recent evaluation of professional development programs concludes that there has been an evolution in programs from learning from external experts to learning from professional reflection on teachers' work. Such a shift has in turn led to an evolution of seeing schools as learning environments, for teachers, instead of only workplaces (Campbell et al., 2017).

Teacher isolation is a significant impediment to professional growth and innovation. Professional Learning Communities (PLCs) are a proven strategy for overcoming this, but they often struggle with logistical challenges or, as seen in the case of Indonesia's Kelompok Kerja Guru (KKG—Teacher Working Group) forums, become co-opted for administrative purposes. AI can help create and sustain more dynamic, effective, and pedagogy-focused professional communities.

Virtual and Asynchronous Collaboration: AI-powered platforms can facilitate virtual PLCs, connecting teachers from different schools, districts, and even countries. This is particularly valuable in contexts where geographical distance or lack of travel funds makes in-person collaboration difficult. Platforms like Disco and Playlab.ai are designed to build these online communities of practice, allowing teachers to share resources, discuss challenges, and collaboratively design lessons asynchronously. Disco is a broader community-building platform that has integrated AI features to make the community more effective and easier to manage. It can automatically summarize long discussion threads, identify key themes or questions that arise, and suggest discussion prompts to keep the conversation going. This helps teachers quickly catch up and engage meaningfully without having to read every single message. Playlab.ai is specifically designed for educators to co-create with AI. Teachers use it to generate drafts of lesson plans, learning activities, and educational materials. The AI acts as a starting point or a brainstorming partner, and then the teachers in the community collaborate to refine, adapt, and build upon the AI-generated content.

Streamlining PLC Operations: Even the logistics of running a PLC can be a burden. AI tools are emerging to help streamline these processes. For instance, Knowt's AI PLC Agenda Generator can automatically create structured, editable meeting agendas based on a PLC's goals and topics. This helps keep meetings focused on substantive pedagogical discussions rather than administrative planning, ensuring that collaborative time is used effectively (Table 6.4).

6.6 Conclusion

This chapter has explored the challenges and opportunities at the intersection of AI and teacher professional development (TPD) in the context of the Global South. Drawing upon the systems perspective and the book's three cross-cutting themes as outlined in Chap. 1, several important insights and actionable implications emerge for policymakers, practitioners, developers, and researchers.

6.6.1 Main Takeaways for Education Policymakers and Practitioners

6.6.1.1 What Is AI Doing, and Not Doing, in Teacher Professional Development?

1. Development of AI Literacy:

TPD programs incorporating AI are beginning to expose teachers to basic concepts of AI, digital pedagogies, and the integration of AI tools in instruction. However, such opportunities are mostly concentrated in urban, well-resource contexts. There is a notable gap in comprehensive, context-sensitive approaches that not only teach the technical but also the ethical, civic, and pedagogical dimensions of AI. Most teachers in the Global South still lack meaningful opportunities to develop deep and critical AI literacy.

The value-add of teachers using AI only exists when there is foundational AI literacy for teachers. Providing access to AI tools without foundational literacy training offers limited value and may be harmful to the goals of education. It can lead to misuse, over-reliance on flawed outputs or deskilling. Simply giving a teacher ChatGPT without training them in pedagogical prompt engineering and critical evaluation of what it produces does not improve their practice; it may worsen it if they use low-quality outputs uncritically.

This literacy transcends mere technical proficiency; it encompasses a critical understanding of AI's core concepts, its ethical dimensions, and its pedagogical implications. Without such grounding, teachers risk becoming passive recipients of AI tools rather than empowered agents capable of making informed decisions about their use. Teachers may learn to operate that tool but not necessarily understand its underlying principles, its limitations, or how to adapt it effectively for diverse learners. In contrast, TPD that focuses on the critical evaluation of AI for bias and pedagogical appropriateness and on strategies for integrating AI thoughtfully into their teaching, empowers teachers to make their own informed professional judgments about if, when, and how to use AI in ways that genuinely support their students and enhance their professional practice.

A comprehensive approach to AI literacy for teachers involves three interconnected pedagogical strands: teaching *about* AI, teaching *with* AI, and fostering the

Table 6.4 Summary: AI competencies & training priorities for educators, in-service and pre-service

Competency domain	Specific competency	Description
1. Foundational Knowledge	AI Concepts & Terminology	Understanding basic AI concepts (e.g., machine learning, NLP, generative AI), their capabilities, and how they function
	AI in the Education Ecosystem	Awareness of how AI can be used across the education system, from student learning platforms to school management
2. Pedagogical and Content Knowledge	AI-Assisted Lesson Planning & Material Generation	Using AI tools to generate, adapt, and differentiate lesson plans, activities, and learning resources.
	Pedagogical Prompt Engineering	Skillfully crafting prompts to elicit high-quality, pedagogically sound, and contextually relevant outputs from generative AI
	AI for Formative Assessment & Feedback	Using AI to design assessments, analyze student work, and provide timely, targeted feedback and information to teachers on where students are at
	AI-Augmented Coaching & Self-Reflection	Using AI-analyzed data (e.g., from lesson recordings) to reflect on and improve one's own teaching practice.
	Simulation-Based Practice	Engaging with AI-powered simulations to rehearse and refine pedagogical skills
3. Critical & Ethical Stance	Critical Evaluation of AI Outputs	The ability to critically analyze AI-generated content for accuracy, pedagogical soundness, and bias.
	Ethical Use of AI	Understanding and applying ethical principles related to data privacy, student agency, consent, and accountability
	Bias Detection & Mitigation	Recognizing how AI can perpetuate societal biases and developing strategies to mitigate these risks in the classroom
	Guiding Student AI Use	The ability to model and teach students how to use AI tools responsibly, critically, and ethically

ability to *critically engage with or against* AI. Teaching *about* AI is how people typically define AI literacy: imparting knowledge of core AI concepts, how AI systems function (e.g., learning from data), and their societal applications and implications. Teaching *with* AI involves equipping educators to use AI tools effectively as part of their instructional repertoire to enhance teaching and learning processes. Critically *engaging with* AI (or teaching "against" AI) empowers teachers to understand AI's limitations, recognize potential biases, discern when AI use is inappropriate or counterproductive, and make informed decisions about its role in the classroom. Given the potential for AI tools trained on non-local data to exhibit biases or produce culturally inappropriate content, teachers must be empowered to scrutinize AI outputs, question their validity, and adapt them to their specific

classroom needs. Teachers must be equipped not only to use AI themselves but also to model responsible practices and instruct students on how to navigate the complexities of AI technologies.

Ministries and their partners should move beyond one-off training workshops and develop a sustained, multi-level TPD strategy focused on building AI Pedagogical Content Knowledge. This involves not just knowing how to use a tool, but knowing how, when, and why to use it for specific pedagogical purposes within a subject.

- Tier 1 (All Educators): Foundational AI Literacy and Ethics. All teachers should receive training on the basics of AI, its ethical implications, including bias in algorithms, data privacy, and how to critically evaluate AI-generated content for accuracy and appropriateness. This builds the "expert curator" skills mentioned in the chapter.
- Tier 2 (Subject-Specific Integration): Provide subject-specific training that demonstrates how AI tools can be used to deepen learning in areas like science, history, and language arts. For example, using AI to simulate historical events, analyze literary texts, or model scientific phenomena. This directly supports the integration of AI across the curriculum rather than just adding it as another subject.
- Tier 3 (Teacher Leaders & Coaches): Advanced Application and Mentorship. Cultivate a cohort of teacher leaders who receive advanced training in prompting, adapting AI tools for diverse learners (e.g., for neurodivergent students as seen in the Peru pilot), and leading professional learning communities (PLCs) where colleagues can share best practices and collaboratively solve implementation challenges.

Integrating AI Literacy into Existing TPD: Models and Examples

To ensure sustainability and widespread adoption, AI literacy should not be treated as an isolated, add-on module but rather be deeply integrated into existing preservice and in-service TPD systems. This approach positions AI literacy as a core competency for modern educators, rather than a specialized skill. MIT's Generative AI for K-12 Educators course provides a comprehensive curriculum that can be adapted for various contexts. UNESCO has also developed AI Competency Frameworks for teachers, offering structured guidance for curriculum development in this area. The adaptation of high-quality, existing AI literacy courses for Global South contexts requires more than mere translation of content. It demands a thorough contextualization of examples, case studies, and ethical dilemmas to ensure they resonate with the local realities, norms, and specific challenges faced by teachers. Furthermore, teachers can learn about AI by applying their new skills to a meaningful and immediately useful task. This hands-on, output-oriented approach to TPD can be more engaging and effective than purely theoretical instruction, fostering a sense of ownership and practical accomplishment among educators.

Improvement of System Effectiveness in Foundational Literacies
AI-enabled TPD initiatives show promise in supporting teachers' mastery of subject content, classroom management, and foundational literacy/numeracy teaching. Interactive digital platforms and peer-coaching networks, sometimes powered or enhanced by AI recommendation systems, can personalize professional learning, offering resources and feedback adapted to teachers' experience and needs. Yet, most systems remain reliant on traditional face-to-face or top-down training models, and access to high-quality, ongoing, and practical TPD powered by AI is still limited and uneven.

Improvement of System Relevance for Twenty-First Century Skills
TPD that integrates AI is beginning to prepare teachers to support students' twenty-first-century competencies: problem-solving, collaboration, creativity, and digital citizenship. However, holistic approaches where teachers co-design learning, engage in reflective practice, and build communities of innovation are still rare. AI-enabled TPD tends to supplement rather than transform these broader capacities at scale.

6.6.1.2 Innovation vs. Transformation

Most uses of AI in TPD presently represent innovation: increased personalization, easier access to resources, or logistical efficiencies in training. True transformation, where TPD fundamentally shifts to become continuous, collaborative, job-embedded, and tightly aligned to system priorities—is rare. The strongest evidence for transformation comes when TPD, curriculum, and ongoing teacher support co-evolve as part of larger systemic reforms. Beyond foundational literacy, AI offers a suite of tools and capabilities that can act as powerful catalysts for pedagogical innovation, enabling teachers to design more engaging, differentiated, and effective learning experiences. From assisting with the intricate task of lesson planning to providing personalized instructional coaching and transforming assessment practices, AI can augment teachers' skills and expand their pedagogical capabilities.

6.6.1.3 Equity and the Digital Divide

AI-powered TPD risks widening existing equity gaps if it is primarily deployed in private, urban, or technologically advanced settings. Teachers in under-resourced rural areas, those with limited digital skills, and non-dominant language speakers often remain excluded from these innovations. Without policies and investments that ensure access and build foundational digital capacity, technological advances will likely reinforce rather than bridge divides in teacher competence and opportunity.

6.6.1.4 Systems Perspective

- Initial Conditions: Teacher readiness, infrastructure, leadership support, and system priorities shape the impact and sustainability of AI-enabled TPD.
- Interactive Effects and Synergies: Effective TPD is achieved when supported by curriculum reform, assessment alignment, mentorship, and peer learning. AI alone cannot substitute for whole-system enablement.
- Feedback Loops: Digital TPD platforms powered by AI can enable just-in-time feedback, diagnose learning needs, and inform policy, but risk being underutilized unless paired with organizational change and teacher agency.
- Small Shifts, Big Impacts: Context-aware, incremental changes, such as digital coaching or resource-sharing, can catalyze larger waves of innovation where conditions allow, illustrating the non-linear effects described in Chap. 1.

6.6.2 Implications for AI Developers and Education Stakeholders

- Operationalizing "Pedagogical AI Content Knowledge" (PACK): The most powerful future applications will not be generic tools but specialized systems co-created with educators.
- Establish National "PACK" Development Hubs: A forward-thinking investment would be the creation of national or regional interdisciplinary hubs. These centers would bring together master teachers, curriculum specialists, and AI engineers with a clear mandate: to co-design, build, and validate AI educational tools (e.g., Socratic tutors, complex simulators) that are deeply embedded with local curricula, languages, and pedagogical values. This approach ensures that the next generation of educational AI is culturally relevant, pedagogically sound, and directly addresses the specific needs of the region's teachers and students.

Furthermore, AI developers should:

- Design for Diversity: Build tools that accommodate varying levels of connectivity, language, pedagogical tradition, and teacher backgrounds.
- Foster Community and Collaboration: Move beyond individual training modules to enable communities of practice, peer coaching, and collective learning journeys.
- Enhance Teacher Agency: Prioritize tools that position teachers as co-designers and critical users, rather than passive recipients, of both technology and professional learning content.
- Avoid Reinforcing Hierarchies: Beware of solutions that centralize control or prioritize monitoring over empowerment, which can erode teacher trust and autonomy.

- What's Missing: There is a lack of holistic, open-source, scalable platforms for TPD that address both contextual constraints and ethical or civic dimensions of AI.

6.6.3 Ethical Questions and Concerns

Key concerns include:

- Data Privacy and Surveillance: AI-based TPD may track teacher behaviors, resource use, or even classroom conduct, raising concerns about consent, purpose, and data protection.
- Access and Fairness: Equity of access to AI-enhanced TPD remains a major challenge; solutions too often serve those already most advantaged.
- Well-being: Digital TPD can contribute to overload, blur boundaries between work and home life, and undermine the "right to disconnect" if not carefully structured.
- Ensuring AI Complements, Not Replaces, Core Teaching Responsibilities: Augmentation vs. Automation. While AI offers tools to support teachers, there are concerns that its uncritical or poorly managed integration could lead to the de-skilling of educators and de-professionalization such as a reduction in their professional autonomy.
- There is a risk of using AI to evaluate, rank, or prescribe teacher actions rather than fostering professional judgment and innovation. A fundamental principle guiding the ethical and effective integration of AI into education is that AI should serve to complement and enhance the work of human teachers, not to replace their core pedagogical responsibilities. The primary objective should be to improve teacher capacity, reduce the burden of rote tasks, and thereby enrich student-teacher and peer-to-peer interactions. Human connection, empathy, mentorship, and the ability to foster critical thinking and socio-emotional development are irreplaceable aspects of quality teaching that AI, in its current form, cannot replicate.

As AI takes on more routine functions, the role of the teacher evolves to focus more intensely on facilitating deeper learning, making meaning of complex concepts, supporting students' holistic development, and sustaining their intrinsic motivation to learn. Ensuring that AI genuinely complements rather than supplants core teaching responsibilities requires a participatory approach to AI development and deployment (Winthrop & Ershadi, 2025). Without teacher input and insights into classroom realities and pedagogical priorities, AI tools might be designed in ways that are misaligned with local educational values, inadvertently undermine essential teaching roles, or fail to address the most pressing needs of teachers and students.

If AI systems become overly prescriptive, dictating curriculum content, pedagogical approaches, and assessment methods with limited room for teacher input or adaptation, there is a risk that teachers could be relegated to mere implementers of AI-driven instructions rather than exercising their professional judgment. In

environments where teachers already face numerous pressures and may have limited access to ongoing professional support, the imposition of complex or pedagogically misaligned AI systems could lead to a compliance-driven, superficial adoption rather than a genuinely innovation-driven integration. This could erode teachers' sense of professional efficacy, creativity, and ownership over their practice.

It is therefore paramount that AI is positioned to empower and augment teaching, not to replace the critical role of the teacher. Teacher agency, the capacity of teachers to make informed decisions and take purposeful action in their professional practice, is crucial for ensuring that AI serves as a supportive and effective tool in the classroom.

Finally, while AI can provide invaluable scaffolding for novice teachers, it can also become a permanent crutch that inhibits the development of their own professional intuition and judgment. The risk is creating a generation of educators who are highly skilled at prompting an AI but lack the underlying pedagogical reasoning to design learning experiences or adapt to unexpected classroom situations without technological assistance.

6.6.4 Emerging Research Questions

Impact on Teacher Development and Retention:

- Does the sustained use of AI for administrative and planning tasks lead to a measurable reduction in teacher burnout and an increase in teacher retention rates over a 3–5 year period? How is the saved time used or reallocated?
- What is the long-term effect of AI-driven instructional coaching on a teacher's pedagogical repertoire, self-efficacy and teaching culture? Do the observed changes in practice persist if the AI tool is removed?
- How does the introduction of AI tools shift the nature and quality of discourse within Professional Learning Communities (PLCs)? Does it deepen pedagogical conversations or re-center them on technical support and prompt engineering?
- Which models of AI-enabled TPD are effective, scalable, and equitable in low-resource environments?
- How does AI-driven feedback influence teacher reflection, practice change, and classroom outcomes?
- What are teachers' experiences and attitudes toward datafication within TPD, and how is agency preserved?
- How can AI and digital platforms support collective, collaborative, and context-specific professional development?

Impact on Student Learning and Equity:

- When comparing classrooms using AI-generated differentiated materials versus those using traditional differentiation methods, are there measurable differences in long-term student learning outcomes, conceptual mastery, and the closing of achievement gaps?

- For students who regularly use AI tutors, what is the impact on their development of metacognitive and self-regulated learning skills? Does it foster independent learning or create a form of cognitive dependency?
- Does the type of AI used in schools correlate with socio-economic status? Are affluent schools more likely to use AI for creative, inquiry-based learning while under-resourced schools are relegated to using it for drill-and-practice, thereby widening existing equity gaps?

Gaps, Misalignments, and a Future Research Agenda

The primary misalignment is the gap between the rapid deployment of AI tools and the much slower development of deep pedagogical knowledge required to use them well. This gap informs our urgent research agenda. The current trend focuses heavily on the *technology* of AI, but the real challenge is *human-centered*: building the capacity of teachers to integrate these tools in service of pedagogy wisely. The risk is a widening chasm where the technology's potential outpaces the profession's ability to harness it effectively and ethically. AI is currently treated as technical problem focussed on other tools rather than a pedagogical or learning problem focused the interaction between people and these tools.

In summary, AI offers pathways to scale, personalize, and potentially transform teacher professional development, but so far, these remain mostly at the level of innovation rather than system transformation. To ensure AI enables rather than impedes equitable professional learning, policy and design must work hand-in-hand: addressing foundational digital access, honoring teachers' agency, and embedding technological advances within robust, context-sensitive, and collaborative professional communities. Only then will AI-powered TPD contribute to systemic, sustainable improvement in learning for all.

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Chapter 7
AI and School Organization and Management

7.1 The Problems: School Leadership and School Organization in the Global South

The previous chapter discussed how support for teachers' development is one of the most important, and proximal, determinants of students' opportunity to learn. We also discussed the evolution of two related ideas in the field of professional development, the first the idea that professional development is a *continuum*, the second the idea that much of that professional development could take place in schools which would require seeing schools not just as workplaces but as learning environments for students as well as for adults. From those ideas follows the implication that one of the most important roles of school leaders is to create a culture in schools that enables such learning for all and continuous, job embedded, professional development for teachers.

Schools across the Global South face persistent and deep-rooted challenges that inhibit their ability to offer opportunities for teachers to develop and for students to learn. As discussed in previous chapters, education systems in the Global South frequently face challenges such as rapid demographic growth and resource constraints. The rapid expansion of mass education with limited resources and top-down hierarchical structures has shaped school structures and leadership roles that constrain school autonomy and limit school leaders' instructional role. As a result, schools are more often seen as implementing units of mandates from above than as learning organizations of professionals where teachers and administrators form part of collaborative networks and have access to the necessary resources to support their ongoing professional development.

As discussed in the first chapter, mass education was achieved standardizing education delivery. A 'factory model' was frequently adopted to increase the efficiency in delivering standardized education and, as a result, school structures today often reflect such goals to standardized education, thus reproducing outdated models of teaching and management. Examples include reliance on rigid timetables,

F. Reimers et al., *Artificial Intelligence and Education in the Global South*,
https://doi.org/10.1007/978-3-032-11449-5_7

age-based grouping of students in grades and progression from one grade to the next, and strict subject compartmentalization. This grammar of schooling (Tyack & Cuban, 1995) of mass education thus results in an organizational grammar that reinforces fragmentation of knowledge and teacher isolation (UNESCO, 2021) and that limits teachers' autonomy and professionalism, and that also constrains the opportunities for personalization of education. Teachers typically work alone behind closed classroom doors, with little collaboration or time for collaborative learning. Students also learn subjects in silos, failing to grasp the interconnections across subjects or across what they learn in different grades. The task of being able to apprehend the interconnection of what is learned in various subjects and across grades is generally left to the student to undertake alone, not the product of intentional school or curriculum design. In this sense, the organization of the school becomes a powerful mediator of the curriculum. This organizational set up requires that students accommodate to the system, rather than the system meeting each student where they are and supporting their particular needs and interests. Just as it has often been said that 'organizational culture eats strategy for breakfast', it could be said that school organization and culture override the most progressive intentions of the curriculum (UNESCO, 2021).

In the standardized mass education system, it is not just students and teachers within schools that work in isolation, similarly, schools also frequently function as isolated units, lacking meaningful connections with other schools, networks, or community institutions. This isolation limits the capacity of schools and the capacity for innovation and collective problem-solving of educators.

This state of affairs creates serious limitations in the capacity of schools to resolve the tensions between foundational learning and twenty-first-century skills discussed in Chap. 3. It is no wonder that so many educators see those propositions as 'either or' rather than 'both and' because the rigidities of the system we have described lead naturally to a scarcity mindset in thinking about what schools and teachers can do. It is unsurprising that many would see as beyond reach that teaching can be interdisciplinary, or that learning foundational skills can be integrated with learning transferable skills, or that each student can be supported to address their particular needs. Enabling schools to deliver more powerful or relevant instruction requires increasing the capacity of schools, engaging teachers in teams and schools in networks with other schools and other institutions is one way to do this, as argued in UNESCO's recent report on the Futures of Education (UNESCO, 2021).

In much of the Global South, schools as organizations are part of school systems where many key decisions are made at the top of the bureaucracy, in the headquarters of the Ministry of Education, and schools are conceived as part of the 'delivery chain' of the designs of ministries, as appendages tasked with implementing mandates from the top, with limited capacity for input in those decisions that impact them or for adaptation, even though it is local teachers and school heads who may have more knowledge about the key challenges that schools need to address, and even the expertise to identify how to address them. In this type of top-down design, leadership is also typically top-down, with principals overburdened by administrative duties imposed from the top, and largely unsupported in areas of instructional

leadership. In rural El Salvador, for instance, principals often lack any formal administrative training and manage schools using paper-based reporting systems, while simultaneously teaching full-time classes. For instance, Fatima, a school principal in La Costa del Sol in El Salvador in her early 50s, begins her day before the sun fully rises. She walks the dusty roads to school, her mind already burdened with the tasks that await her. Her school, like many in the region, faces significant challenges: limited resources, overcrowded classrooms, and a chronic shortage of teaching materials. Despite these obstacles, Fatima's commitment to her students and teachers never stops. Upon arriving at school, Fatima is immediately occupied with a mountain of responsibilities. Her office, a small room with a desk piled high with papers, is a testament to the administrative burden she carries. She manages student registrations, teacher schedules, school finances, etc. The lack of digital tools means much of her work is done on paper, a time-consuming process that often extends well into the evening. Fatima's role is primarily administrative, leaving her with little time for instructional leadership or community engagement. She spends most of her day in her office, dealing with paperwork and attending to the endless stream of administrative tasks. Her ability to observe teachers, offer guidance, or engage with parents is severely limited. She dreams of being more present in the classrooms, of mentoring her teachers and building a stronger sense of community, but the reality of her situation often makes these aspirations feel out of reach.

The financial constraints in the Global South add another layer of complexity to these leadership challenges. For many schools in low- and middle-income countries, the cost of implementing AI solutions is prohibitive. This includes not only the initial expenditure on technology and infrastructure but also ongoing maintenance and training costs, which can strain already limited budgets.

As highlighted in the 2024/5 Global Education Monitoring Report, school leaders in the Global South often operate without clear job descriptions, adequate professional development, or access to digital tools (UNESCO, 2024). Their responsibilities are expansive, ranging from finance to family engagement to student well-being, yet they are rarely equipped with the capacity, time, or authority to lead transformation. Recent evidence confirms that strengthening school leadership can be a cost-effective way to improve student learning in the Global South, yet this avenue for quality improvement remains underutilized (Global School Leaders Alliance, 2024). While effective leadership, particularly instructional leadership, has been shown to positively influence student outcomes, many school leaders lack the training, mentorship, time, and enabling conditions needed to translate their roles into better teaching and learning within their schools.

This situation has severe implications for school effectiveness. School effectiveness, defined as the degree to which a school can achieve educational goals given its context and available resources (Scheerens, 2000), depends heavily on instructional leadership, a positive school climate, and the ability to use data to improve practice. Yet most school leaders in the Global South are poorly equipped to play this role. They are expected to support teacher development, engage with families, and drive school improvement, but with minimal training, outdated systems, and no time, authority or capacity for innovation. Scheerens identifies instructional leadership,

clear educational goals, structured school climate, frequent monitoring of progress, and teacher collaboration as central to school effectiveness. Most schools in the Global South struggle to meet these criteria due to structural constraints.

Moreover, school leadership tends to reproduce the hierarchical and non-participatory modes of system-level leadership. Teachers are rarely involved in making decisions, and principals usually lead on their own instead of working together with others. According to the GEM Report (UNESCO, 2024), professional learning for principals often focuses on financial and administrative tasks rather than on pedagogy, innovation, or the use of digital tools. In many systems, leaders are not empowered to make instructional decisions or engage in reflective practices, undermining the goal of continuous improvement. In order to build trust within these systems, this will require fostering open communication, involving stakeholders in decision-making processes, and demonstrating consistent, transparent actions that prioritize the educational community's well-being.

7.2 How Can AI Support More Effective, Empowered, Empowering and Networked School Leadership?

AI offers new possibilities for transforming how schools are organized and led, particularly in under-resourced settings. Beyond simply automating administrative tasks, AI can help redesign the fundamental functions of school leadership: fostering collaboration, improving data use, connecting curriculum with assessment and instruction, and enabling instructional support.

One of the most transformative roles AI can play is in overcoming the siloed nature of teacher work and school organization. AI-supported platforms can enable networks of schools to collaborate, share data, and co-develop professional learning programs. For example, AI can look at data from different schools in an area, find schools with similar problems, and help them work together or learn from each other. This kind of networking, largely absent in traditional systems, is essential to building collective leadership and shared learning cultures (UNESCO, 2021).

For school leaders, AI tools can support the shift from task management to instructional leadership, especially as schools are facing increasing administrative burdens that often divert resources from their key missions. AI offers the opportunity to address this by streamlining administrative tasks. Adaptive dashboards, for example, can summarize student performance trends, highlight absenteeism patterns, or recommend tailored professional development for teachers. AI can also support alignment between curriculum, instruction, and assessment by analyzing learning outcomes and helping principals adapt school strategies accordingly (UNESCO, 2024). Instead of static reports, school leaders could receive real-time, visual insights that connect classroom data with school improvement plans.

Most importantly, AI can make the invisible visible. Many school leaders today lack the ability to interpret or act on education data. Predictive analytics and machine

learning tools can surface patterns such as which students are most at risk of dropout or which classrooms have persistent learning gaps and suggest targeted actions. AI can integrate different types of data, such as attendance, test scores, and teacher observations, to build multidimensional indicators of student engagement and learning (Molina et al., 2024). In doing so, AI empowers leaders to make timely, equity-focused decisions, especially when paired with training in data literacy and ethical interpretation. While AI offers promising solutions, it is crucial to consider cost-effective approaches that are accessible for schools in the Global South. Leveraging existing infrastructure and open-source technologies can help mitigate financial barriers, making AI solutions more feasible in resource-constrained environments.

AI can also support new forms of participatory leadership. Automated surveys, chatbots, and sentiment analysis tools can collect feedback from teachers, parents, and students. This feedback can be synthesized and displayed on leadership dashboards, helping school leaders respond to community needs, improve communication, and build trust (Pedro et al., 2019).

By relieving school leaders of repetitive tasks and enabling better coordination, AI can allow them to focus on core leadership functions: setting vision, supporting teachers, engaging the community, and building inclusive school cultures. A recent UNESCO Futures of Education report argues, "leaders must move from command and control to participatory and collaborative modes of organizing" (UNESCO, 2021). AI can support this shift by creating time and tools for reflection, responsiveness, and shared decision-making.

Recent global evidence, including the UNESCO (2023) Global Education Monitoring Report, provides timely guidance on the transformative, but complex, role of technology and AI in school organization and leadership. UNESCO notes that the digital transformation of education intensifies the responsibilities and opportunities of school leaders: not only to ensure equity in access to digital resources, but also to maintain a strong people-centered culture within schools.

Leaders are encouraged to see technology as a tool for deepening inclusion, participation, and learning, not merely as an end in itself or a shortcut to administrative efficiency. As digital platforms, management information systems, and AI-driven analytics become more widespread, leaders must ensure their adoption is grounded in context, responsive to the needs of teachers and learners, and accompanied by robust policies on data privacy, digital rights, and transparency. The report also warns against a top-down, "one-size-fits-all" approach; instead, it advocates for distributed leadership and shared decision-making, supported by digital collaboration tools that foster team learning, peer support, and networked innovation.

UNESCO emphasizes the need for ongoing professional development for school leaders on the pedagogical, managerial, and ethical dimensions of technology. Such training empowers leaders to evaluate technology critically, lead change with confidence, and build adaptive, resilient school cultures that value both data-driven insights and human relationships. Finally, amidst growing digitalization, school leaders must remain vigilant in protecting the well-being of staff and students: addressing issues of workload, screen time, surveillance, and digital safety as part of a holistic vision of school effectiveness (Table 7.1).

Table 7.1 Comparative overview of school leadership challenges and potential AI-driven opportunities

Key school leadership challenges	Potential AI-driven opportunities/interventions
Siloed teacher work and lack of collaboration between schools; limited opportunities for shared professional learning	AI-supported platforms to connect networks of schools, identify similar challenges, and foster collaborative problem-solving
Heavy administrative burdens diverting leaders from instructional leadership	AI to automate paperwork and routine tasks, freeing leaders to focus on pedagogy and teacher support
Limited use of education data; leaders often lack capacity to interpret or act on it	Adaptive dashboards for real-time visualization of trends (attendance, performance, absenteeism); predictive analytics to identify at-risk students and suggest interventions
Weak alignment between curriculum, instruction, and assessment	AI to analyze learning outcomes, recommend instructional adjustments, and link classroom data to school improvement plans
Resource constraints in the Global South limit access to advanced systems	Cost-effective AI solutions leveraging existing infrastructure, open-source tools, and low-bandwidth platforms
Limited participatory leadership and feedback loops with the school community	Automated surveys, chatbots, and sentiment analysis to gather and synthesize feedback from teachers, parents, and students
Risk of top-down, "one-size-fits-all" technology adoption	AI-enabled leadership tools to support shared decision-making, team learning, and peer collaboration
Insufficient training on the pedagogical, managerial, and ethical use of AI	Ongoing professional development for leaders on data literacy, ethical AI interpretation, and technology management
Balancing digital transformation with staff and student well-being	AI tools for workload monitoring, digital safety alerts, and balanced tech use policies

7.3 What Is AI Already Doing in Support of Better School Leadership? Current Use Cases and Research

AI applications are already making a difference in schools across the Global South. These include administrative automation, data-driven decision support, resource optimization, and leadership transformation.

7.3.1 Administrative Automation

AI tools can take over repetitive, time-consuming tasks such as student registration, managing teacher absences, and creating class schedules. For example, DRUID is an AI platform specifically designed for higher education institutions, primarily used in North America. It is implemented in institutions like Georgia Southern University and West Georgia, where it has been used to improve student

engagement and streamline operations. DRUID can answer queries 24/7, assist teachers, and automate processes like payroll and onboarding (Molina et al., 2024). In Nigeria, cloud-based AI systems have reduced administrative workloads, freeing time for instructional leadership (eSchool.ng, 2024). AI can support schools in overcoming language barriers when working with diverse communities. For example, at a primary school in Czechia, staff members rely on AI-based translation tools to improve communication with students and parents: 15% of whom are from abroad, including countries such as Afghanistan, Ukraine, and Mongolia (Microsoft, 2025). Tools such as this can be adapted to school leadership, enhancing the ability of school leaders to focus on strategic and instructional tasks by reducing the time spent on administrative duties.

7.3.2 Data-Driven Decision Support

AI helps school leaders make faster, more accurate decisions by organizing and visualizing data in real time. These dashboards bring together key indicators—attendance, test scores, teacher reports—and highlight patterns or areas of concern. In the Global South, the government of Andhra Pradesh, India, has worked with Microsoft to deploy a machine learning–based application to predict school dropout. Drawing on data such as enrolment, academic performance, socio-economic background, school infrastructure, and teacher qualifications, the system identifies more than 60 patterns linked to dropout risk, from outdated curricula to lack of functional toilets for girls. Since 2019, over 10,000 schools in the state have used this tool to guide interventions and prioritise investments (OECD, 2021). Another example is Chile, where an AI-powered early warning systems identifies students at risk of dropping out due to poor attendance or declining performance, prompting timely interventions (Molina et al, 2024). A Global North example comes from Germany, where the LAPS (Learning Analytics for Exams and Study Success) project at Stuttgart Media University uses machine learning to spot students at risk of failing early in their studies. Since 2014, it has generated semesterly reports for faculty and participating students, flagging over 200 possible risk factors (from declining grades to repeated exam withdrawals) while respecting privacy, voluntary participation, and anonymity. The system also supports quality assurance, providing detailed programme-level data such as dropout rates, grade averages, and demographic profiles (OECD, 2021). When such systems link to national Education Management Information Systems (EMIS), they become even more powerful. By leveraging AI in conjunction with national EMIS, educational systems can become more adaptive, responsive, and effective. This integration supports a shift from reactive to proactive management, enabling educational leaders to anticipate challenges, optimize resources, and implement interventions that are informed by comprehensive, real-time data analysis.

AI can support distributed forms of leadership, such as those based on use of data to develop improvement plans. An example is the Data Wise improvement process,

developed at the Harvard Graduate School of Education. This is an eight-step cycle that builds collaborative data inquiry habits among school teams: (1) Organize for collaborative work, (2) Build data literacy, (3) Use student stories to ignite curiosity, (4) Dig into evidence of learning, and four additional steps focused on actions, alignment, and improvement. While AI itself is not part of the Data Wise process, using them together can enhance how schools analyze and use data. When schools use AI tools together with data based collaborative improvement approaches such as Data Wise, they can shift from collecting data occasionally to consistently improving teaching through collaboration. This approach enhances professional development, turning it from passive training into practical, evidence-based strategies.

Data Wise encourages teams to regularly review evidence, identify patterns in student learning, and adjust instruction in response. When AI-powered dashboards are integrated into this process, they speed up data aggregation and visualization, enabling staff to spend more time interpreting results and planning improvements. Research shows that when Data Wise is implemented, with strong leadership support and technology, teachers engage in deeper professional learning and students show gains in achievement (Harvard Graduate School of Education, 2020).

By combining AI tools with data-based improvement approaches such as Data Wise, schools can move from sporadic data collection to sustained, collaborative instructional improvement, elevating professional development from passive training to actionable, evidence-based practice.

7.3.3 Resource Optimization

AI can improve the allocation of human and material resources. Ecuador's "Quiero Ser Maestro" platform uses algorithms to match teachers with schools based on qualifications, location, and subject needs, reducing inequity and inefficiency (Elacqua et al., 2022). In Peru, during COVID-19 closures, an AI-assisted system reassigned over 100,000 students to alternative schools, ensuring balanced enrollments and continued access to schooling (Molina et al., 2024). In Uruguay, predictive analytics forecasted procurement needs for educational materials, equipment, or infrastructure based on historical data and forecasts of prices and demand, optimizing spending (Molina et al., 2024).

7.3.4 Leadership Transformation

By reducing paperwork and streamlining administrative processes, AI can free up school leaders' time to engage in instructional leadership: observing classrooms, mentoring teachers, and planning learning improvements. Rwanda's national strategy emphasizes this shift from administration to pedagogy (UNESCO, 2024). Consultative tools like DRUID can collect feedback automatically, answer

questions at any time, and send personalized messages to teachers, parents, and students. DRUID helps schools stay connected with their communities and makes it easier for leaders to understand and respond to what students, teachers and parents need (Molina et al., 2024). AI can also strengthen parent–school communication through intelligent reporting systems. Increasingly, parents receive digital "eReports" on their children's learning and activity, delivered through web-based portals, mobile apps, or even automated text messages (OECD, 2021). These range from high-level alerts (e.g., a student is at risk of dropping out) to mid-level updates (e.g., the student has seven absences or is earning a C in mathematics) to detailed item-level feedback (e.g., which question was missed and why). Platforms such as ASSISTments provide parents with data on recent assignments, performance, and correct answers, while tools like Edgenuity share time-on-task metrics and pacing information. By making this information available in real time, school leaders can reduce the manual burden of communication, ensure parents are informed promptly, and identify issues earlier. When reports are designed for usability, they have been shown to improve parental engagement and student outcomes (Bergman & Chan, 2017; Kraft & Monti-Nussbaum, 2017).

In the health sector, similar tools have proven effective in improving leadership. For example, Laguna Insights, used by clinics, automatically summarizes patient information before calls and offers real-time cues on empathy and tone (Pillay, 2024). This enables more meaningful dialogue and stronger patient-provider rapport. Similarly, platforms like Feedtrail apply real-time sentiment analysis to flag dissatisfaction quickly, helping administrators and clinicians respond proactively to patient concerns. These tools support staff well-being, improve communication, and foster a responsive, collaborative workplace culture.

In education, similar AI tools can significantly enhance leadership effectiveness. By providing real-time feedback and insights, AI can help school leaders:

- Enhance Communication: Automatically summarize and communicate important information to teachers, parents, and students, ensuring everyone is informed and engaged.
- Improve Responsiveness: Quickly identify and address concerns or areas of dissatisfaction, allowing leaders to take proactive measures to improve school climate and student outcomes.
- Foster Collaboration: Facilitate better collaboration among staff by providing platforms for sharing insights, best practices, and resources, thereby creating a more cohesive and supportive educational environment.
- Support Decision-Making: Offer data-driven insights and recommendations that align with school values and educational goals, enabling leaders to make informed decisions that enhance teaching and learning.

These tools strengthen communication, well-being, and trust, which are increasingly relevant for education. By leveraging AI, school leaders can focus more on instructional leadership and less on administrative tasks, ultimately leading to more effective and impactful educational outcomes (Table 7.2).

Table 7.2 AI use cases supporting school leadership in the Global South

Category	Description	Examples
Administrative Automation	AI automates repetitive tasks (registration, scheduling, payroll), reducing leaders' administrative load and freeing time for instructional leadership	DRUID platform in U.S. higher education for 24/7 query handling, onboarding, and payroll (Molina et al., 2024); eSchool.ng in Nigeria reducing admin workload (eSchool.ng, 2024)
Data-Driven Decision Support	AI organizes and visualizes key indicators (attendance, performance, teacher reports) to spot risks and guide interventions	Andhra Pradesh, India ML system predicts dropout using 60+ risk patterns (OECD, 2021); Chile early warning system flags at-risk students (Molina et al., 2024); Germany LAPS system identifies failing risks & supports QA (OECD, 2021)
Collaborative Data Use for School Improvement	Combining AI-powered dashboards with improvement cycles enhances collaborative decision-making and PD	Data Wise process from the Harvard Graduate School of Education, integrated with AI dashboards to accelerate data analysis, enable continuous instructional improvement (Harvard Graduate School of Education, 2020)
Resource Optimization	AI improves matching of human and material resources to needs, reducing inequity and inefficiency	Ecuador "Quiero Ser Maestro" matches teachers to schools (Elacqua et al., 2022); Peru reassigns 100k+ students during COVID-19 closures (Molina et al., 2024); Uruguay uses predictive analytics for procurement (Molina et al., 2024)
Leadership Transformation	AI frees leaders to focus on pedagogy, strengthens communication with stakeholders, and improves responsiveness	Rwanda shifts from administration to pedagogy (UNESCO, 2024); DRUID collects feedback & sends personalized comms (Molina et al., 2024); Parent eReports (ASSISTments, Edgenuity) improve engagement & outcomes (OECD, 2021)
Cross-Sector Insights for Education Leadership	Adaptation of AI communication and sentiment tools from other sectors (e.g., health) to education leadership	Laguna Insights auto-summarizes info & cues empathy (Pillay, 2024); Feedtrail sentiment analysis flags dissatisfaction early. Potential in education for real-time feedback, school climate monitoring, and staff well-being support

7.4 Conclusion

This chapter delved into the evolving landscape of school organization, management, and leadership in the era of artificial intelligence, with a special focus on the unique challenges and potential of the Global South. Through analysis grounded in the book's three cross-cutting themes and a systems lens, we draw key conclusions for policymakers, practitioners, developers, and researchers.

7.4.1 Main Takeaways for Education Policymakers and Practitioners

What is AI doing—and not doing—in school organization and leadership?

AI should not be viewed merely as a tool to improve efficiency but as a mechanism to reimagine leadership and equity in schools. Drawing on UNESCO's Futures of Education report *Reimagining Our Futures Together* (UNESCO, 2021), schools must evolve into participatory, inclusive spaces where leadership is shared, and learning is embedded in relationships of trust and care. In practice, this means:

7.4.1.1 Development of AI Literacy

School leaders play a critical role in cultivating AI awareness and ethical AI use within their institutions. While some leaders are beginning to access training on digital and AI tools for data management, resource allocation, and monitoring school performance, widespread AI literacy among leaders, staff, and communities is still in its infancy. Leadership development often remains disconnected from the broader drive for AI literacy across the teaching workforce and student body. Training school leaders in data literacy and ethics, alongside digital skills, is essential. Leaders must be able to interpret and utilize data effectively, identify trends, monitor progress, and make informed decisions, while ensuring ethical safeguards and responsible use of technology.

7.4.1.2 Improvement of System's Effectiveness

AI-enabled school management systems can support data-driven decision-making, efficient resource management, and targeted interventions for student support. In some contexts, AI tools allow for more effective monitoring of attendance, learning progress, and operational tasks, freeing up leadership time for instructional development. However, these tools are not yet driving large-scale improvements in foundational learning unless tightly aligned with instructional leadership and school culture reform. AI should be positioned to amplify human judgment, not replace it, ensuring that final decisions remain grounded in professional expertise and ethical considerations.

7.4.1.3 Improvement of System's relevance in Developing Twenty-First-Century Skills

AI-powered platforms sometimes facilitate professional learning communities, collaboration among schools, and the sharing of best practices, laying the groundwork for more innovative school cultures. Yet, evidence of AI fostering distributed

leadership, cross-disciplinary teams, or the authentic cultivation of twenty-first-century skills (such as adaptability, creativity, or social-emotional competencies) is still limited. Many initiatives focus on administrative efficiency rather than transforming norms of collaboration or instructional vision. To shift from innovation to transformation, AI tools should be designed to support collaboration. This involves creating platforms that enable stakeholder voice (teachers, students, parents) in decision-making, shared learning, and equitable resource access.

7.4.1.4 Innovation vs. Transformation

Most current AI-related initiatives in school management represent innovation: incremental improvements in efficiency, scheduling, or targeted interventions. Few reach the scale of transformation, where AI catalyzes new forms of participatory leadership, reimagined school organization, and fundamentally student-centered environments. The strongest cases for transformation emerge in holistic reforms where leadership, teacher development, school organization, and technology co-evolve into learner-centered, networked, adaptive systems.

The challenge is not to digitize existing control structures but to transform them, breaking with outdated "grammar of schooling" (Tyack & Cuban, 1995) and fostering open, collaborative cultures.

7.4.1.5 Equity and the Digital Divide

There is a real risk that AI-enabled management and leadership tools reinforce existing divides, given that pilot projects and most implementations occur in private or urban schools. Leadership in under-resourced or rural schools often lacks access to reliable data, infrastructure, or the professional development needed to harness AI's potential.

Policymakers must prioritize local capacity building and infrastructure investment (ensuring reliable internet, hardware provision, and local technical expertise) and adopt a participatory design process with continuous feedback loops to adapt tools to real-world needs.

7.4.1.6 Systems Perspective

- Initial Conditions: Impact depends on pre-existing school culture, leadership vision, resourcing, and staff readiness.
- Synergies: Organizational innovation succeeds when AI is integrated with team development, teacher PD, shared decision-making, and community engagement.
- Feedback Loops: Schools that foster continuous system learning—using data to inform iterative organizational change rather than just compliance reporting—exemplify the power of a systems perspective.

- Small Changes, Big Results: Seemingly minor tweaks (e.g., data-enabled communication flows; collaborative planning tools) can, where trust and structures exist, drive significant improvement in school climate and performance.

Ultimately, as Scheerens (2000) notes, effective leadership includes instructional guidance, goal-setting, progress monitoring, and fostering collaboration. These remain the foundations of school improvement. AI can enhance these practices—reducing administrative load, enabling timely insights, and facilitating communication—but only when governed wisely and embedded within a broader social contract for education. School effectiveness should not be measured solely by outputs, but also by the institution's capacity to nurture equitable, resilient, and human-centered learning communities.

7.4.2 Implications for AI Developers

For AI developers:

- Contextualize Solutions: Co-develop tools with school leaders that fit local realities, sensitive to connectivity, cultural context, and operational needs.
- Empower, Don't Disempower: Design AI tools that augment rather than replace human judgment, and help foster instructional not just administrative leadership.
- Foster Collaboration: Provide platforms that support collaboration within and across schools, facilitating shared learning rather than siloed, top-down management.
- Transform, Don't Just Tweak: Go beyond digitizing existing routines to create tools that help rethink structures, roles, feedback, and participatory processes.
- What's Missing: Most current platforms neglect inclusive practice, distributed leadership, and connections between data use, well-being, and holistic school improvement.

7.5 Ethical Questions and Concerns

This chapter surfaces several ethical challenges:

7.5.1 Digital Divide and Equity

AI risks deepening existing inequities if introduced without adequate investment in infrastructure, training, and ongoing support. For example, as the UNESCO GEM Report highlights, 70% of rural schools in India lack internet access, and only 22%

of schools in sub-Saharan Africa have reliable electricity (UNESCO, 2024). Without addressing these disparities, AI tools may widen the gap between well-resourced urban schools and underserved rural or marginalized communities.

7.5.2 Algorithmic Bias and Fairness

AI systems trained on historical data reflecting existing social inequalities risk perpetuating or exacerbating those biases. This is especially concerning when AI influences high-stakes decisions like student placement or teacher evaluations. Ethical AI frameworks, such as UNESCO's Recommendation on the Ethics of AI (2021), stress the importance of preserving human agency, ensuring transparency in algorithms, and fostering participatory governance to mitigate bias and unfairness.

7.5.3 Power Dynamics and Local Agency

There is a significant risk that AI, especially when centrally controlled, could increase top-down monitoring and standardization, limiting the professional judgment of school leaders and local educators. As Scheerens (2000) warns, overly prescriptive improvement models can undermine local ownership and the adaptive capacities of schools. Therefore, AI should be designed as a tool to support, not replace, school leaders, empowering autonomy, reflection, and context-sensitive decision-making rather than enforcing compliance.

7.5.4 Data Privacy and Trust

Schools handle sensitive personal information about students, families, and staff. AI systems must rigorously protect this data, comply with ethical standards, and maintain transparency about data usage and decision-making processes. Trust is fundamental to effective school leadership, and breaches of privacy can rapidly erode confidence. Robust security measures, open communication, and clear, timely responses to any data breaches are essential components of ethical AI deployment in education.

7.5.5 Cost and Accessibility

The financial barriers of implementing AI solutions in low-resource settings raise further ethical concerns. Beyond the initial investment in technology and infrastructure, ongoing maintenance and training costs can strain limited budgets, potentially excluding the most underfunded schools. Therefore, AI solutions must be designed with affordability, scalability, and local capacity-building in mind to ensure equitable access across diverse contexts in the Global South. Without proactive design, AI will continue to benefit schools already advantaged by infrastructure, talent, and capital.

7.5.6 Inclusivity and Participation

Digitization risks marginalizing non-digital forms of knowledge and closing off opportunities for participatory, bottom-up leadership that values teacher and community voice. Ethical AI integration should intentionally include diverse stakeholders and ensure digital tools enhance—not replace—human relationships and democratic governance in schools.

7.6 Emerging Research Questions

- How can AI-enabled school management tools be equitably implemented in low-resource settings?
- What leadership development models best prepare leaders to use AI for school improvement, while maintaining ethical safeguards?
- How can data-driven management be linked to instructional leadership and student well-being, rather than simply administrative control?
- What systems structures foster the scaling of collaborative, distributed leadership enabled by digital platforms?
- What are the long-term effects of AI-based organizational routines on school culture, staff agency, and student outcomes?

In summary, AI holds real potential to empower more adaptive, data-rich, and collaborative school organizations and leadership, especially when integrated within broader systems change. Realizing this promise, however, demands deliberate attention to context, inclusion, trust, and ethics. Only through whole-systems alignment, where organizational innovation, human leadership, and digital tools support one another, can AI become a lever for lasting transformation in school effectiveness and equity.

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Chapter 8
AI and Education Governance

8.1 Introduction

Education governance is a ripe space for AI adoption and utilization. Education governance relates to the structures, rules and processes within education systems through which decisions are made, priorities are set, resources are distributed, and programs are implemented, monitored, and evaluated. Effective models and approaches to governance in the education sector are critical for the delivery of high-quality education that is inclusive, accessible, and effective. Education governance involves multiple stakeholders and levels of government within an education system, including national or federal actors such as ministries of education, as well as state- or provincial- level organizations, school districts, and individual schools, teachers, and students. Governance approaches across education systems globally may differ based on the extent to which a system is decentralized, and the degrees of autonomy granted to each stakeholder or level of government. Key decisions such as teacher and principal management, resource allocation and management, planning, organization of instruction may occur at the school, local, regional or sub-regional, state, or central levels with varying degrees of autonomy (OECD, 2018). While activities such as the grouping of pupils in classes generally occurs at the school level in most countries, many decisions that influence school functioning are made at central or state levels, such as establishing salary levels, hiring and promotion decisions, designing programs of study, determining the duration of instruction, defining the school calendar or assessing student, teacher or school performance.

For the purposes of this chapter, we begin with an exploration of present challenges in education governance. We then imagine the possibilities of how AI can enhance education governance addressing key challenges, alongside the opportunities offered by the capabilities of AI technology. Following this imaginative, future-casting exercise, we explore existing applications of AI that address one or several of these governance components to articulate how education governance may be enhanced or even reimagined with the availability of AI, drawing from a range of

F. Reimers et al., *Artificial Intelligence and Education in the Global South*,
https://doi.org/10.1007/978-3-032-11449-5_8

applications in the field of education, as well as those in adjacent areas from which we can draw inspiration.

Notably, the subsequent examples in this chapter do not address the governance of AI in education, which concerns the regulations and policies to govern the use and adoption of AI in education contexts rather than the use of AI in education governance—deeper analysis on this topic is beyond the scope of this book. The emerging topic of how AI use in education should be governed is one on which global multilateral organizations such as UNESCO and OECD have offered guidance to governments and public institutions exploring this issue. For example, the UNESCO 2023 Global Education Monitoring Report, highlights the evolving role of education governance in an increasingly digital world. UNESCO cautions that the integration of technology—including AI—into education systems must always serve clear educational aims: advancing inclusion, quality, and equity, rather than being technology-driven for its own sake. UNESCO's report asserts that while AI holds promise for education, it also brings significant governance challenges and risks. Effective AI governance in education means creating comprehensive, rights-based, ethical, and participatory frameworks to ensure AI supports, rather than undermines, equitable and quality learning for all. The report underscores that AI governance must address:

1. Ethical and Responsible Use:
    - Governance frameworks must ensure that AI in education is used ethically, safely, and in the best interests of learners.
    - The UNESCO Recommendation on the Ethics of Artificial Intelligence (2021) sets out international principles—including transparency, accountability, privacy, human oversight, and inclusiveness—for the use of AI in education.
2. Data Privacy and Protection:
    - AI systems gather and process large volumes of student and staff data, raising heightened concerns about privacy, consent, and data security.
    - UNESCO calls for robust data governance, including clear rules about what data are collected, how they are stored, who has access, and for how long, with specific protections for children and other vulnerable groups.
3. Addressing Bias and Fairness:
    - AI algorithms may reinforce or amplify existing biases and inequalities if not carefully designed and monitored.
    - Governance mechanisms are needed to audit algorithms for fairness and to ensure that AI does not deepen educational disparities.
4. Transparency and Accountability:
    - Decisions made or informed by AI in education should be transparent and explainable to educators, students, and parents.

- There should be clear lines of accountability for adverse impacts or mistakes arising from AI use.

5. Inclusive and Participatory Policymaking:
   - The development and governance of AI in education should involve all stakeholders—governments, educators, learners, families, and communities—to ensure that diverse perspectives and local needs are reflected.
6. Regulation and Oversight:
   - UNESCO emphasizes the urgent need for regulatory frameworks specific to AI in education.
   - These regulations should address issues of child protection, ethical commercial practices, and the prevention of harmful surveillance or misuse.
7. Capacity Building and Ongoing Evaluation:
   - Governments and education authorities require technical expertise and policy capacity to govern AI effectively.
   - Continuous monitoring and evaluation are essential to assess the real-world impact of AI and to update governance in light of new challenges or risks.

Effective governance in this context demands attention to both opportunity and risk. Digital tools can enhance decision-making through improved access to timely data, more transparent resource allocation, and more precise monitoring of outcomes. At the same time, governance frameworks must address challenges of equity—ensuring marginalized communities are not left further behind, and that data-driven approaches do not overshadow local needs or teacher and learner voices. Participatory approaches, where educators, families, and communities are involved in shaping technology policy, support the legitimacy and local relevance of reform.

UNESCO further emphasizes safeguarding privacy, data protection, and digital rights as core responsibilities of education governance. Systems must remain vigilant against commercial interests, overreach, and unintended biases in algorithmic decision-making. Policy coherence is crucial: digital strategies should be integrated into broader education goals, and capacity-building is needed at all levels—central, local, and in schools—to make effective use of technology-enabled governance tools.

Ultimately, the promise of technology in education governance will only be realized if it is guided by principles of transparency, participation, equity, and the continuous balancing of innovation with protection for all learners.

Additionally, while previous chapters have focused on actors within education systems such as students, teachers, and principals, and processes such as curriculum, teacher development and leadership, this chapter considers the implications of AI use on governance stakeholders, particularly policymakers and program managers overseeing the design and implementation of education policies.

8.2 The Problem: Governing a Complex System

As discussed in Chap. 1, education systems are complex because of the multiple goals they pursue, their scale, and the large number of stakeholders with varied interests. In addition, education systems have effects that are long term. The results of an education policy or program are seldom immediate. Policies typically evolve over time, and numerous external factors influence their outcomes, creating challenges in isolating the specific effects of any one policy. Education systems are also in interaction with their external environment, affected by cycles of elections, trends in the labor market, advances in technology, and cultural shifts. This complexity makes governance challenging. While good governance is essential to ensuring that resources are well managed to advance goals in education, examples of poor or ineffective governance are rampant. We highlight several challenges in education governance in the following domains: accountability, capacity, use of data and information, resource management and allocation.

8.2.1 Accountability

Accountability, the simple process of accepting responsibility for the consequences of one's actions, is a cornerstone of effective governance. If education governance is to ensure access to a quality and equitable education it is crucial that those making decisions that influence educational opportunity can accept responsibility for the consequences of their decisions. For example, if a teacher decides to promote all students to the next grade regardless of whether they have learned the required material, the teacher must take responsibility for the consequences of that decision. These may include students being unable to meet expectations in the next grade because of knowledge gaps resulting from the teacher's actions. Or if a district education officer appoints teachers based on criteria other than merit, that officer needs to take responsibility for the consequences of that choice. These may include students' inability to meet learning expectations because the teachers assigned to them lack the necessary skills. Accountability in education governance remains a challenge, particularly in low-resource environments where processes and outcomes cannot be easily linked and traced. Indicative of accountability challenges are declining levels of education performance despite increasing investments in many systems, which suggests that increasing financial commitments to education are used to fund resources and activities which do not translate into opportunities to learn (Mbiti, 2016). Without mature and interlinked data systems, it is difficult to ensure that allocated budgets reach their intended beneficiaries without leakage, a polite term for corruption or mismanagement. Additionally, many countries struggle with accountability gaps, where there is a lack of clarity over accountability structures: "which actors at which levels should be held accountable for which outcomes", creating loopholes for the abuse or misuse of resources (Burns et al., 2016).

This is especially true in decentralized education systems, where more stakeholders are involved in the exchange and transfer of resources. In many developing countries, the separation of certain functions across organizational levels makes it challenging to enforce accountability. For example, hiring and paying teachers often occurs in a centralized agency. As such, in cases of high levels of teacher absenteeism it is difficult for parents and principals to hold such teachers accountable given the distance and inaccessibility of the relevant authority (Mbiti, 2016).

Yan offers a helpful categorization of different ways that accountability can be exercised in education, through: (1) choice and competition (e.g. school vouchers); (2) autonomy and participation (e.g. decentralization, school-based management); and (3) threat (e.g. sanctions based on inspection results or student outcomes) (2019). While numerous education systems globally have tried different variations of these approaches, reforms have been implemented with varying degrees of success. Accountability standards and information, where present, may not be transparently or clearly communicated to stakeholders (Yan, 2019). Further, there may be a misalignment of on-the-ground incentives faced by teachers, parents, and schools, and the incentives and mechanisms of accountability measures. Teacher absenteeism is a telling example, whereby teachers are perceived as self-seeking agents for failing to show up to class for several months and rigorous accountability standards are imposed on them without addressing possible underlying causes behind their absence such as insufficient pay and wages, leading to 'moonlighting' (Bennell, 2022; UNESCO International Institute for Educational Planning, 2022). Conflicting political incentives or ideologies may also lead to poor adoption of well-intended and accountability-based reforms within education systems. As education systems evolve it will be necessary to consider how accountability can be exercised successfully, and importantly, allow for innovation and growth which can often be stifled with strict compliance measures (Burns & Köster, 2016).

More generally, as some education systems choose to introduce higher levels of autonomy to lower levels of government or smaller implementation units, it may be more challenging to ensure alignment and coherence across levels. Inefficiencies in administrative processes as systems grow in complexity, size, and fragmentation can inhibit effective governance.

The challenges of accountability in education governance might be reframed into two key opportunity areas:

- How might we strengthen accountability within education systems, particularly in low-resource contexts?
- How might we shift from accountability for compliance, to accountability as a tool for improvement?

8.2.2 Capacity

Education governance is also affected by the lack of capacity, or the resources, competencies, and capabilities required for stakeholders to perform policy functions and adapt to new developments in education across levels (individual, organization, and systemic) and including varying components (analytical, operational, and political) (Yan, 2019; Wu et al., 2015). A salient capacity domain pertains to teacher capacity, a topic we discussed in Chap. 6, but capacity pertains to the entire administration of the system, involving school principals, which we discussed in Chap. 7, as well as administrators at all other levels. Capacity is interlinked with the accountability challenges discussed above, as the implementation of accountability reforms may be hampered by the lack of local capacity to effectively take advantage of the autonomy and choice offered by the likes of school choice or voucher-based programs (Yan, 2019). Capacity issues manifest in the education governance system in many ways, including: insufficient knowledge of the education policy goals or global best practices, the lack of tools and resources to implement well-intended policies and programs, or potentially a lack of willingness to implement reforms due to limited ownership (Burns & Köster, 2016). A pervasive capacity gap across low-resource education systems surrounds the use of data for decision-making to realize improvements in learning outcomes. While an impressive amount of data is now available for analysis and to support the enforcement of accountability measures (e.g. student assessments, school evaluations, performance indicators, budget use), the ability to make use or make sense of this information is not a given (Burns & Köster, 2016). Local administrators, educators, school leaders, and policymakers would benefit greatly from the capacity to effectively and accurately utilize high-quality data to introduce targeted improvements into their respective education systems. The following two questions highlight emerging opportunities in addressing capacity gaps to enhance education governance:

- How might we rapidly build individual capacity in low-resource education systems?
- How might we supplement existing capacity gaps in low-resource education systems?

8.2.3 Use of Data and Information

In large, complex, education systems, the ability to access, request, or receive data or information may be particularly challenging and hamper effective governance. There are varying types of information that are relevant in this context, including: (1) information related to performance (e.g. access to school, assessment results, school or teacher evaluations); (2) information related to the availability of resources (e.g. teacher workforce) (3) information related to the utilization of resources (e.g. implementation, expenditure); and (4) information related to demographics and the

environmental context (e.g. population data, rural/urban distribution, legal or political factors). Countries in the Global South often struggle to receive or access this information on a timely basis. This may be due to the lack of infrastructure or appropriate data management systems, such as digital platforms or data dashboards, or in certain cases relevant data may not be collected due to limited capacity or resources. In cases where there is limited digitalization or automation of data collection and reporting, or possibly a heavy reliance on manual reporting, there may also be issues with data integrity, quality, and consistency. Further, data may be challenging to integrate, especially across heterogeneous sources, systems, and applications. This challenge is exacerbated in decentralized environments, where education data is collected, handled, and managed across school, district, sub-national, and national levels. As a result, it is difficult to use data to inform strategic decisions, enforce accountability measures, improve resource allocation, and monitor or evaluate interventions and programs. When exceptionally large policy-practice gaps emerge, as was the case in Sub-Saharan Africa where despite the introduction of distance learning policies in over 90% of countries in response to COVID-19, in practice, less than 30% of households received any form of distance education (Angrist & Dercon, 2024), timely access to data to monitor implementation and service delivery would have been a powerful tool to quickly identify and address challenges and inefficiencies.

Aside from the collection and utilization of data, the dissemination of data and information is also a critical component of effective education governance. In large, decentralized education systems, information on education reforms, new programs, or policies has to travel across multiple levels to reach target stakeholders such as teachers and school principals. This long information delivery chain opens up the possibility of misinterpretation and inaccurate sensemaking with limited opportunities for correction, leading to poor or suboptimal implementation of otherwise well-designed policies. Additionally, information is rarely presented in a user-centric manner—with insufficient information, or overly complex information in technical or jargonistic language, disadvantaging those without a technical background or with lower literacy levels (Garcia, 2011; Delale-O'Connor, 2018; Yan, 2019).

On the issue of data and information use, we might consider these two opportunities for innovation:

- How might we develop and implement user-centric, integrated data systems that facilitate real-time access to high-quality, comprehensive education data across all levels of an education system?
- How might we optimize the dissemination of critical information within an education system to ensure it is accurately interpreted, easily accessible, and presented in a user-friendly format for all stakeholders?

8.2.4 Resource Management and Allocation

Resource allocation is key to improving education systems. When finances, personnel, and even infrastructure are not appropriately allocated to students, schools, or districts, it is difficult to realize improvements to education outcomes. As an example, Namibia has spent an average of 23% of its total government expenditure on education over the past decade, yet spending has not been optimal enough to yield proportional improvements in learning outcomes (UNICEF, 2016). A closer examination of Namibia's education budget shows that textbook budgets were disproportionately high in secondary schools, despite studies highlighting that textbook usage is most effective in early years of schooling to mitigate teacher shortages, variance in quality, and large class sizes common in low-income countries (UNICEF, 2016). Many countries struggle with similar challenges of suboptimal resource allocation, representing a missed opportunity to use knowledge on the effectiveness of varying interventions to improve education spending.

- How might we empower education policymakers and practitioners with accessible data and actionable insights on the effectiveness of different educational interventions, enabling them to make more informed and equitable resource allocation decisions?
- How might we develop and implement evidence-based frameworks and tools to guide resource allocation in education, ensuring that finances, personnel, and infrastructure are strategically deployed to maximize learning outcomes?

While accountability, capacity, data and information, as well as resource management and allocation challenges persist across complex education systems globally, the section above also highlights the range of opportunities that are present for innovation. We explore these opportunities in greater detail in the following section, envisioning how AI might hold promising answers to these questions.

8.3 What AI Could Do: Enhancing Education Governance with AI

The questions we pose offer helpful domains to explore how AI might be part of a comprehensive approach to strengthening accountability, building capacity, increasing access to data and information, and improving resource allocation and management. While the answers to these questions may not solely lie in AI adoption and deployment, we focus on particular applications of AI recognizing that other factors and approaches may be equally valid, feasible, and impactful (Table 8.1).

To answer these questions we consider the unique value-adds and mechanisms of artificial intelligence technology, and how they might apply to each of the dimensions of governance listed above.

Table 8.1 Prompting questions to identify areas of opportunity across four dimensions of education governance

Accountability
• How might we strengthen accountability within education systems, particularly in low-resource contexts?
• How might we shift from accountability for compliance, to accountability as a tool for improvement?
Capacity
• How might we rapidly build individual capacity in low-resource education systems?
• How might we supplement existing capacity gaps in low-resource education systems?
Data and Information
• How might we develop and implement user-centric, integrated data systems that facilitate real-time access to high-quality, comprehensive education data across all levels of an education system?
• How might we optimize the dissemination of critical information within an education system to ensure it is accurately interpreted, easily accessible, and presented in a user-friendly format for all stakeholders?
Resource Allocation and Management
• How might we empower education policymakers and practitioners with accessible data and actionable insights on the effectiveness of different educational interventions, enabling them to make more informed and equitable resource allocation decisions?
• How might we develop and implement evidence-based frameworks and tools to guide resource allocation in education, ensuring that finances, personnel, and infrastructure are strategically deployed to maximize learning outcomes?

One of AI's greatest value-adds is in the way that we interact with AI tools—as experienced by many through popular platforms such as ChatGPT, Gemini, and Claude, the simplicity of the language with which we ask questions and write prompts is no more complicated than how we would write or speak in real life. This is a stark contrast to the specialized knowledge or language (e.g. understanding programming languages or codes) that are required by other tools to perform specific tasks. The simplicity of this interaction is made possible by Natural Language Processing (NLP) in AI tools, which allows AI applications to both comprehend and generate human language. This is immensely valuable in addressing the capacity challenge in education governance at present, as it reduces the barriers to utilizing AI. Previously, a policymaker would typically require months or years of training on topics such as data analysis to gain a baseline level of proficiency, including the use of various softwares to extract meaningful insights from large datasets. Now, they are able to use their own words to instruct an AI application to conduct the same task. Similarly, while up-to-date knowledge regarding global best practices in education may have been inaccessible due to paywalls or dependence on experts, a simple search enhanced by AI can now surface the latest practices and evaluation findings from academia, multilaterals, and leading think tanks. Necessarily, the effectiveness of interactions will differ based on the quality and comprehensiveness of the prompt provided, and on the quality of the corpus of text on which the AI application is trained, however this already offers tremendous utility in low-resource

settings where budgets for training, consultancy, and other capacity-building approaches may be constrained.

Secondly, AI makes sophisticated analyses required for effective education governance accessible. There are a number of highly time-consuming and complex tasks that are required for effective education governance, including analyzing various sources and formats of data, developing forecasting models related to demand or distribution of resources based on certain constraints (e.g. time, budget), systematically reviewing literature regarding the effectiveness of different education interventions, or translating complex policy documents into various formats and levels of technical language difficulty based on the target stakeholder. AI tools leverage machine learning algorithms to process vast amounts of diverse data forms to identify historical patterns and forecast future probabilities based on past trends. Importantly, as additional data becomes available, algorithms finetune their predictions for greater accuracy. These algorithms are also able to optimize for multiple objectives and offer insights to varying levels of granularity, which would otherwise be immensely time-consuming to produce. These are powerful mechanisms to enable constant, real-time monitoring, and continuous evaluation which then informs simulations of various policy implementation options (Filgueiras, 2023).

Third, AI's value-add in the context of education governance lies in the speed and accuracy with which AI tools can complete complex tasks. This is powerful in a governance context, because the speed with which a human can recognize patterns, read texts and data, and synthesize information is inherently limited by capacity and ability. The same tasks can be completed in a fraction of the time with AI tools. The pace at which analysis is conducted with the support of AI tools addresses a present barrier to effective governance. Currently, insights on implementation are often not produced in a timely manner, and the feedback chain from an observation on the field to a shift in policy or program design is outpaced by developments in the field. The constant monitoring and processing capability offered by AI tools, especially those which leverage automation, circumvents these challenges.

The possibilities unlocked by AI usage in education governance also bring to light the uniquely human skills that will become increasingly critical to ensuring that it retains its value-add, rather than creating additional concerns. As analytical tasks are outsourced to AI tools, human judgment to review the results, accuracy, and logic of analytical outputs will be key. Humans shift from executors to editors and managers of the analysis process. Discerning between factual and nonsensical outputs, as well as developing robust testing methodologies to ensure accuracy, will be key uniquely human roles, especially if analytical outputs carry large consequences for the distribution of funds and other resources. Human critical judgment is essential, and this might mean introducing AI into the process in a sequential or gradual way i.e. only when there is sufficient understanding of the types of analyses to conduct, the methodology and risks surrounding various analytical approaches, to be able to then review outputs and identify errors.

In Filgueiras' exploration of various AI in education scenarios, the author highlights how AI's value-add to education builds upon the platformization of education through the growing number of digital tools available to support teaching and

Table 8.2 Comparative overview of education governance challenges and potential AI-driven opportunities

Key challenges	Potential AI-driven opportunities/interventions
High barriers to using traditional data analysis tools—Policymakers previously needed months/years of training to extract insights from datasets	**Natural Language Processing (NLP)** enables policymakers to interact with AI tools using everyday language, removing the need for advanced technical skills
Limited access to up-to-date global best practices in education due to paywalls, dependence on experts, or slow research dissemination	AI-enhanced search tools can surface the latest research, policy briefs, and best practices from multiple credible sources in real time
Time-consuming, complex governance tasks such as multi-source data analysis, forecasting, literature reviews, and translation of policy documents	Machine learning algorithms can process large, diverse datasets, forecast resource needs, review literature systematically, and adapt documents to different audiences quickly
Delayed decision-making due to slow analysis and feedback loops between field observations and policy changes	AI-powered automation and real-time monitoring enable continuous evaluation and rapid generation of actionable insights, speeding up policy responses
Risk of over-reliance on AI outputs without human oversight—possibility of inaccurate or illogical recommendations affecting high-stakes decisions	Integrating human oversight as "editors" and "managers" of AI analyses to validate accuracy, logic, and methodology before implementation
Need for strong digital infrastructure to host and integrate AI applications, especially in low-resource contexts	Pairing AI adoption plans with digital platform development strategies to ensure foundational systems are in place for AI tools to function effectively

learning, as well as develop and enhance individuals' intellectual capacity (2023). It is with these digital platforms that artificial intelligence technologies can be leveraged to unlock value. This same observation, however, highlights a constraint which low-resource countries may consider as they think about the adoption and use of AI tools—the need for digital platforms to first be in place and usable (Table 8.2).

8.4 What AI Is Doing to Improve Governance

8.4.1 Resource Allocation

Cities in the United States such as Pittsburgh, Pennsylvania, and Fort Worth, Texas have used Priority Based Budgeting approaches supported by AI and machine learning tools to identify patterns and connections across spending and programs (National League of Cities, 2025). Access to AI modelling tools to process program and budgetary data, supported with research on areas of impactful and effective education spending, can be a powerful combination to better inform decisions

surrounding resource allocation and spending in education in a more rapid and efficient manner.

Aside from financial allocation challenges, education systems often struggle with human resource allocation to achieve an equitable distribution of teachers across levels and regions. These can be attributed to both supply-side challenges, such as teacher demographics and preferences, as well as demand-side distribution challenges, including recruitment and hiring processes, deployment practices, and misalignment between supply and demand (Luschei & Chudgar, 2016). To this end, Guyana's example of deploying AI and matching algorithms to improve the teacher placement process may serve as a useful reference to improve the quality of information and matches to improve teacher distribution across countries (IIEP, 2025).

The use of AI to improve matching issues is consistent across other fields such as public health and workforce planning more broadly, with varying tools using AI algorithms to improve match quality with semantic searches and matching across multiple dimensions (e.g. location preferences, availability) to achieve greater accuracy and efficiency. In the U.S., for example, the National Resident Matching Program ("The Match") pairs graduating medical students with residency programs using an optimization algorithm that considers applicants' and programs' ranked preferences, geographic constraints, and capacity limits. Newer tools are integrating AI and semantic matching to enhance prediction of program–applicant fit, much like AI-enabled workforce systems in other sectors. Workforce planning software such as Workday's Skills Cloud, Visier, SAP SuccessFactors, and Anaplan have integrated AI-based capabilities to offer workforce needs prediction, skills gap assessments, and dynamic workforce allocation adjustments. While these are largely private-sector solutions, they serve as a source of inspiration for how government owned and operated applications might be structured.

8.4.2 Strategic Planning

Strategic planning is critical in education governance, as it ensures that there is a clear roadmap and strategy towards improving education outcomes. Strategic plans highlight priorities, goals, and guide decision-making in education systems. While high-resource countries are often able to access education consultants or hire dedicated teams to conduct strategic planning, low and middle-income countries (LMICs) may not have the same resources at their disposal. AI tools, depending on their accessibility, affordability, and quality, may be a helpful alternative that offers guidance based on best practices in education to improve education governance in the global south.

Planning is greatly enhanced with predictive capabilities, allowing planners to make forecasts which influence potential resource allocation decisions or programmatic considerations beyond the immediate term. AI tools offer an opportunity to improve predictive capacities, allowing for better resource deployment, preparation, and matching to local needs.

Finland, for instance, has introduced Osaamistarvekompassi (Skills Needs Compass) under the Service Centre for Continuous Learning and Employment (SECLE) to improve the quality of skills and job matching (OECD, 2024). This was a response to the limited number of upskilling opportunities available to working-age Finnish adults due to a lack of reliable and accurate anticipatory labor market data. Finnish education providers did not have access to data that could be used to shape training programs. As a result, a data platform and website was created to offer updated future skills needs data. AI is used as part of this initiative to structure and refine skills needs data according to the Finnish National Agency for Education's latest skills classification, allowing for more effective data utilization, mapping of job transition opportunities, and data-informed funding allocation for continuous learning services and programs offered by SECLE. Additionally, the agency intends to use AI to assist in analyzing skills needs data in relation to publicly funded training opportunities available in Finland. Estonia has also introduced a similar big data analytics approach to improve skills matching and alignment between the labor market needs and education outcomes (IIEP, 2025).

Aside from matching, the use of data in decision-making is also core to strategic planning efforts in education. AI algorithms offer the added value of data analysis for trend identification, predictive capacities, and potential recommendations for preventative intervention (Hamer, 2024). This approach is transferable to education governance, with parallels between patient data and student or teacher data to inform resource allocation, placement, and the distribution of opportunities for career development. AI has also been deployed as part of the Mexican state of Guanajuato's Secretariat of Education (SEG)'s Early Action System for School Permanence (SATPE) to address the state's high dropout rate of 40,000 students per year, which preemptively identifies at-risk students, allowing the SEG to introduce timely personalized supports and interventions to improve student retention (Pinto, 2023; OECD, 2022b). In São Paulo, the State Court of Auditors (TCESP) has collaborated with the University of São Paulo to enhance the state's strategic planning capacity through a new analysis approach, the School-Effect Indicator (IEE). The IEE methodology uses AI to calculate the expected grade a student may receive on the National Basic Education Assessment System (SAEB), controlling for socio-economic factors. This expected grade is compared with the student's observed grade to identify the value-add of the school towards student performance. AI is used to process large amounts of data to conduct this calculation and improve the prediction model, while the resulting analysis is used by the TCESP in the public audit to identify high- and low-performing schools (OECD, 2023).

From school management to policy development, AI assists in resource allocation, attendance monitoring, and identifying systemic issues (Majkić & Vranjes, 2024). Case studies such as the "Teach to One" math program in the United States and the BYJU's learning platform in India illustrate large-scale adoption of AI for instructional innovation and system-wide data analysis (Vincent-Lancrin and van der Vlies, 2020).

In Chile, Student Success is a management support system focused on data use to prevent school dropout, based on the integration and analysis of data on personal

characteristics of students, academic achievement and others (Rivas, 2025). A similar early warning application in the province of Mendoza, Argentina analyzes student trajectories identifying those at risk of dropping out and mobilizing various support networks to prevent it (Rivas, 2025).

A related case is the University of Wollongong in Australia, which faced the challenge of adopting learning analytics across the institution while working with different teaching cultures and proving the value of analytics to both staff and students. Despite having a strong data warehouse system, the university still needed extra staff for analytics and big data work. They involved students in the design process, collected their opinions on privacy and preferred features, and set up two governance groups: one for managing the adoption process and another for ensuring ethical use of student data. Key lessons from this case include using a shared technology infrastructure, engaging students early, creating communities of practice, and establishing clear governance for learning analytics (Heath & Leinonen, 2016, as cited in OECD, 2021).

8.4.3 Monitoring and Evaluation

Monitoring and evaluation of policies through reviews and analyses of education performance data, as well as feedback and constituent engagement, support more effective education governance. Depending on the size and scale of education governance systems, it is often challenging to collect and synthesize feedback from various constituents including teachers, students, parents, principals, or even subnational leads. To this end, platforms such as GoVocal empower governments with integrated platforms that allow citizens to engage in the policy process on budgeting, new proposals, and local development plans. Engage Stirling is a platform powered by GoVocal, used by the Stirling Council in Scotland that has already been used to gather public feedback and conduct community consultations on various education issues including increasing school capacity in specialist secondary schools, and distributing financial support under Scotland's early learning and childcare program for which the government funds 1,140 hours of early learning for all 3 and 4 year olds (Fillet, 2023). GoVocal's platform is equipped with dashboards, as well as built-in AI which allows policymakers and government representatives to organize and analyze input for deeper and more efficient analyses. Constituent feedback then informs subsequent policy decisions and strategic actions, closing and speeding up the feedback loop in education.

Part of education governance also requires timely responses to constituent complaints to ensure that education services are delivered and issues are addressed. Uruguay's national government has used Natural Language Processing (NLP) techniques to automate the classification of 82% of service requests, processing over 33,000 requests every year with greater efficiency, effectiveness, and accuracy (OECD, 2022a). The incorporation of the algorithm developed by the E-Government and Information and Knowledge Society Agency (AGESIC) has dramatically

reduced the response time to addressing citizen concerns, freeing up public officers' time for higher-value added tasks such as offering solutions, rather than classifying and allocating documents based on request types. The solution's design has been made open and uses open source tools, making it replicable to other areas of government for consideration in other contexts—including education. In education governance, large volumes of requests from university administrators, parent groups, district education offices, and school principals on issues ranging from clarifications of new education policies or legislature, to technical issues and data requests can require substantial resources and energy to navigate and address. Thoughtful deployment of AI to improve service requests and resource matching stands to bring great benefits to education governance.

Importantly, outcome and impact data is not consistently available for the various references of AI use shared above—some deployments of AI only make output data available, if any quantitative metrics are reported at all. This points to the need for more consistent and robust reporting of impact and outcome metrics across AI deployments, especially in education governance where AI use may not necessarily be structured as a randomized control trial or a targeted quasi-experimental intervention as seen in classroom deployments for students and educators (Table 8.3).

8.5 Conclusion

This chapter has examined the implications of artificial intelligence (AI) and technology for education governance, focusing on the complexities and opportunities confronting systems—especially in the Global South. Through the lens of the book's core themes and a systems perspective, several critical lessons and recommendations emerge for policymakers, practitioners, AI developers, and researchers.

8.5.1 Main Takeaways for Education Policymakers and Practitioners

What is AI doing—and not doing—within education governance?

8.5.1.1 Development of AI Literacy

AI is beginning to influence governance structures by enabling new forms of data-driven planning, policy analysis, and oversight. However, there is still a limited focus on advancing AI literacy among system-level actors. Most policymakers, administrators, and governing bodies lack deep understanding of both AI potential and its risks, leaving systems underprepared for ethical, transparent, and effective

Table 8.3 AI use cases in education governance

Category	Description	Examples and sources
Resource Allocation	Use of AI to optimize financial and human resource allocation in education systems, improving efficiency and equity	Priority Based Budgeting in Pittsburgh, PA, and Fort Worth, TX using AI to identify spending patterns (National League of Cities, 2025); Guyana's AI and matching algorithms for teacher placement (IIEP, 2025); Ecuador's teacher-school matching platform (Elacqua et al., 2022)
Strategic Planning	AI-enhanced forecasting and data integration to inform education policy, skills alignment, and long-term planning	Finland's Osaamistarvekompassi for skills needs prediction (OECD 2024, 2023) Estonia's big data analytics for labor market–education alignment (IIEP, 2025); Guanajuato, Mexico's Early Action System for School Permanence (SATPE) for dropout prevention (Pinto, 2023); São Paulo's School-Effect Indicator for performance analysis (OECD, 2023)
Early Warning Systems and Retention	Predictive analytics to identify at-risk students and trigger timely interventions	SATPE in Guanajuato, Mexico (Pinto, 2023); Student Success system in Chile (Rivas, 2025); Mendoza, Argentina's dropout prevention platform (Rivas, 2025)
Learning Analytics and Institutional Adoption	AI tools to analyze learning data, inform teaching strategies, and guide institutional change while addressing ethical and governance concerns	University of Wollongong's learning analytics governance and adoption process (Heath and Leinonen, 2016, as cited in OECD, 2021)
Monitoring and Evaluation	AI-powered platforms for citizen engagement, policy feedback, and performance tracking	GoVocal and Engage Stirling for public consultations and education policy feedback (Fillet, 2023)
Service Request Management	NLP and automation to classify and route service requests, reducing response times and improving efficiency	Uruguay's AGESIC NLP solution processing 82% of service requests automatically (OECD, 2022a)

oversight. To address this, it is essential to ensure the appropriate foundations for AI usage are in place before adoption. This means developing a strong supporting data ecosystem, clear governance processes for how AI recommendations are considered, maintenance and monitoring plans, risk reviews, and sustainable funding. Uruguay's careful change-management approach with AGESIC addressing concerns about public funds and human resource impacts illustrates this point.

8.5.1.2 Improvement of System Effectiveness in Foundational Literacies

AI-powered dashboards and analytics promise earlier detection of systemic breakdowns in literacy or numeracy, more efficient allocation of resources, and targeted interventions. There is growing use of digital data to track attendance, teacher deployment, and learning outcomes. Yet, challenges remain in translating information into action—especially where governance capacity, data quality, or cross-level cooperation are weak. Improved foundational outcomes rely on aligning AI-enabled monitoring with coherent, responsive system action. AI use must be complemented by holistic capacity-building, training teams, public officers, and staff to confidently use AI tools, understand the role of AI vis-à-vis human judgment, and anticipate biases and misrepresentations. Guanajuato's integration of AIF360 bias detection alongside staff training on AI ethics demonstrates the value of pairing technology with human capability development (Pinto, 2023).

8.5.1.3 Enhancement of Relevance for Twenty-First Century Skills

AI governance tools can facilitate monitoring and support for broad curricular goals, including citizenship, digital literacy, and socio-emotional learning. Nevertheless, most oversight remains focused on traditional metrics and accountability, with relatively few innovations supporting the development and measurement of twenty-first-century skills at scale. Cross-sector collaboration is critical to closing this gap. Partnerships—such as the University of São Paulo with TCESP, SECLE with Solita/Digitalist/HeadAI, and Stirling Council with GoVocal—have been central to deploying AI effectively where in-house technical capacity is limited. In such collaborations, governance priorities must lead, and technological innovation should serve as an enabler, not a driver, of education goals.

8.5.1.4 Innovation vs. Transformation

Much of the current integration of AI in governance represents incremental innovation: improved data flows, more granular analytics, and faster reporting. True transformation—where AI supports distributed, participatory governance; catalyzes adaptive and context-sensitive policy; or fundamentally reimagines accountability structures—is still rare. Examples of AI enabling bottom-up participation from schools and communities, or enabling rapid learning cycles across the system, remain limited and typically depend on broader reforms and leadership vision. Such transformation will only occur if AI adoption is planned with strong foundations, capacity-building, and multi-sector collaboration, rather than as isolated technological fixes.

8.5.1.5 Equity and the Digital Divide

There is genuine risk that AI-enabled approaches to governance further marginalize under-resourced regions, as sophisticated data tools and analytic capacity tend to cluster in central ministries or urban hubs. Gaps in infrastructure, human capacity, and voice mean that marginalized populations may remain invisible in—or even further excluded by—digital governance innovations. Foundational readiness and equitable access strategies must be built into all AI governance initiatives from the outset.

8.5.1.6 Systems Perspective

- Initial Conditions: Technical, cultural, and policy starting points fundamentally shape AI's effectiveness in governance.
- Interactive Effects and Feedback Loops: The most promising AI-enabled governance innovations occur when real-time data, local actor engagement, and responsive policies interact in a virtuous cycle—though such feedback loops remain rare and fragile.
- System Dynamics: Small enhancements in one node of the governance structure—such as data transparency or stakeholder inclusion—can yield outsized effects when supported by aligned resources and leadership. However, isolated technological fixes risk being neutralized or even producing unintended negative consequences in complex systems.

Without evolving underlying planning and decision-making processes, even advanced AI tools will have limited systemic impact.

8.5.2 Implications for AI Developers

Developers supporting AI-enabled governance should:

- Prioritize Transparency and Trust: Co-create tools that allow policymakers, school leaders, and communities to understand, question, and guide AI-assisted decision-making.
- Design for Capacity and Context: Recognize the constraints and local realities of governance in the Global South, building tools that support—not overwhelm—existing systems and that are flexible to local policy and infrastructural environments.
- Enable Participatory Governance: Develop platforms and analytics that foster inclusion, allowing for multiple stakeholders, especially those at the school and community level, to have agency and voice.
- What's Missing: Current tools often lack modules for ethics, child protection, or the tracking of non-academic dimensions of school quality.

8.5.3 Ethical Questions and Concerns

Key ethical considerations include:

- Data Privacy, Security, and Ownership: The collection and centralization of sensitive student and teacher information raise questions of informed consent, data use, and security.
- Bias and Accountability: AI tools risk amplifying or obscuring pre-existing inequalities if their designs, assumptions, or oversight structures are not transparent and regularly evaluated for fairness and relevance. While AI usage in education governance is promising, its success relies on extensive amounts of data, mature education data ecosystems, and adequate digital infrastructure. Without robust, high-quality data, AI-supported recommendations risk being irrelevant or inaccurate. Stakeholders must strengthen governance frameworks, infrastructure, standardization, and a culture of data use, as these elements underpin planning, monitoring, and resource allocation.
- The careless application of AI tools can reproduce or increase biases present in training datasets. For example, Guanajuato's AI-based early warning system explicitly targeted gender bias prevention, using IBM's open-source AI Fairness 360 (AIF360) to identify that 4 in 100 secondary-school girls were incorrectly flagged as dropout risks (Pinto, 2023). The team transformed the data to correct for bias, and this process—paired with stakeholder training in AI ethics and risks—illustrates how mitigation strategies must be embedded from the outset.
- Voice and Participation: As decisions are increasingly driven by data and algorithms, there is a risk of eroding the agency and voice of frontline educators, families, and marginalized communities.
- Commercial Interests: The entry of private AI providers into governance raises important questions about conflict of interest, proprietary algorithms, and public good.
- Capacity and Caution: Education governance stakeholders should adopt a measured approach to AI adoption, with sufficient training and capacity building to ensure clear understanding of risks and use of mitigation tools (such as AIF360) to address potential biases.

8.5.4 Emerging Research Questions

- How can AI tools be designed to support inclusive, transparent, and participatory governance across diverse education systems?
- What models of AI-enabled monitoring and evaluation actually lead to improved outcomes for marginalized learners?
- What are the most effective approaches for building AI literacy and data capacity among policymakers, administrators, and local stakeholders?

- How do different approaches to algorithmic transparency and accountability in governance affect trust and legitimacy at all system levels?
- What regulatory frameworks are most effective in safeguarding data privacy and balancing public benefit with private sector involvement in educational governance?
- What additional value can be created from greater efficiency in education governance processes, and how can freed capacity be used most effectively?
- What new forms of accountability become possible when AI provides real-time system performance insights, and what metrics or feedback loops best enhance accountability to students, parents, and communities?
- What new empowerment opportunities arise when AI insights are accessible across governance levels, and which decisions can be effectively decentralized to the 'middle tier' of actors?

Across the various implementation cases shared in this chapter, it is evident how AI can offer a boost to existing education governance processes. AI can further optimize decision-making and improve the responsiveness with which education stakeholders address challenges such as student dropouts, resource allocation and distribution, performance improvement, and public consultation. However, its effectiveness is highly contingent upon the availability and quality of data within a particular context.

Several shifts in AI-enhanced education governance can already be observed:

- Integration across data sources, allowing for richer and deeper analysis of education data.
- Speed and efficiency, through automation of education data analysis and expanded processing capacity.
- Proactive and dynamic interventions rather than reactive responses, given the predictive and real-time capabilities of AI-integrated tools.

However, AI will not create a significant shift if the underlying processes for planning do not evolve as well. It may be worth rethinking how and where decisions get made—for example, could teacher appointments be localized using AI's ability to offer real-time data and analytics on teacher supply and student needs?

In summary, AI is beginning to reshape education governance, with promise for more adaptive, transparent, and efficient systems. However, evidence of genuine transformation, particularly in equity, participatory decision-making, and meaningful oversight, is still limited. Moving forward, system actors and developers must prioritize transparency, inclusion, and ethical stewardship—aligning digital tools with the deeper goals and values of public education to ensure AI becomes a force for positive systemic change.

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Chapter 9
Conclusion: Charting the Future of AI and Education in the Global South—Promises, Realities, and the Path Forward

9.1 Introduction: Reconnecting with the Systems Perspective

This book has explored the fast-evolving intersection of artificial intelligence and education in the Global South through the lens of systems thinking and human-centered design considering effects on the user, community, and society. In Chap. 1, we positioned education systems as dynamic, complex ecologies: a web of interconnected institutions, actors, values, curricular frameworks, pedagogical practices, assessments, and governance structures, all conditioned by the broader social and economic realities in which they operate.

We warned against techno-optimism and the dangers of "solutionism," advocating instead for open-minded, critical inquiry and an ethic of humility. The promise of AI in education cannot be understood in isolation, particularly in fragile systems where initial conditions, such as infrastructure, teacher capacity, and inequality, exert powerful influences. We highlighted three cross-cutting themes to orient our investigation:

1. The imperative to cultivate AI literacy for all, positioning AI as an object of learning and a potential tool to equip students with the co-intelligence necessary to participate in a world of ubiquitous AI.
2. The urgent necessity to enhance system effectiveness for foundational literacies: literacy, numeracy, and other basic content of the curriculum.
3. The challenge and opportunity of making education systems more relevant to the needs of twenty-first-century societies, economies, and democratic cultures.

Throughout the book, we adopted the systems perspective to examine both direct and indirect effects of AI implementations, foregrounding interactive effects, feedback loops, the role of initial conditions, and the persistent risk of unintended consequences. Now, at the book's conclusion, we synthesize what has been learned, offer guidance for policymakers and practitioners, suggest opportunities for further development, identify ethical questions and some research questions.

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https://doi.org/10.1007/978-3-032-11449-5_9

In reading these conclusions we should remember the caveat that we underscored in the introductory chapter. Our conclusions are limited by the knowledge base we were able to access. This knowledge base, relying on published work, is likely a year or more behind actual developments in the field. When we say that we did not find applications in AI to address particular challenges we mean literally that we did not find them, not that they don't exist. It is possible that they exist and they haven't been documented or evaluated. The second limitation is the greater availability of applications of AI in education in the context of schools; by necessity this limits uses of AI to support learning independently or in non-formal settings. These may exist, but we don't cover them here. When we say that most applications to date are focused on the delivery of the curriculum, rather than on empowering learners to create their own curriculum, this refers to what is happening in school settings which has been documented. It is very possible that AI has made much independent learning, outside the context of schools, possible, but those uses are not captured in the knowledge base on which we rely.

9.2 The Education Challenges in the Global South

As detailed in Chap. 2, education systems in the Global South face a set of interrelated challenges. While basic access to schooling has dramatically expanded, deep disparities persist in access, learning outcomes, resources, and opportunity. The learning crisis remains acute: millions of children are in school but not achieving minimum proficiency in foundational skills. These deficits are shaped by poverty, conflict, gender, disability, language barriers, and the lingering legacies of exclusionary education systems, as well as underfunding, teacher shortages, and weak governance capacity that limit the effectiveness of reforms. Rural-urban divides and the particular struggles of displaced and refugee learners further increase inequities.

Crucially, technology, AI included, exists against this backdrop, carrying the risk of exacerbating existing divides as much as bridging them. Many innovations in educational technology are accessible only to the privileged, deepening rather than resolving exclusion. While AI and digital tools hold immense potential to leapfrog constraints, they can also entrench inequalities, particularly where access to devices, connectivity, high-quality content, and skilled teachers is patchy or absent.

AI in education must never be a goal in itself but be used in service of broad educational purposes, helping individuals realize their potential and strengthening communities for the challenges of this century. Integration must be context-driven, inclusive, and evidence-informed.

9.3 Students and Learning: AI's Promise and Limits in Addressing Student Diversity

A modern education system's legitimacy lies in its ability to offer all students meaningful opportunities to learn. AI, in theory, is ideally suited to respond to diverse learning needs, offering personalization, adaptive pacing, multilingual delivery, and on-demand scaffolding.

However, as documented, the current reality is far from this ideal. Most AI-empowered learning platforms are found in private, urban, or pilot project settings, often benefitting those already most advantaged. The examples we have identified do not typically focus on marginalized learners: those with disabilities, living in rural settings, or lacking digital access.

- AI Literacy: Where initiatives exist, they are sporadic, focusing narrowly on technical coding or digital literacy, rarely reaching scale or addressing ethical and critical dimensions.
- Foundational Literacies: Adaptive learning systems are supporting the development of basic skills, but only when well-aligned with needs, capacity, and ongoing teacher support.
- Twenty-First-Century Skills: There are some examples of AI used to support project-based teaching and to develop transversal skills such as critical thinking, but access is limited, and they seem to be supplementary activities rather than integrated with the curriculum.

The innovation-to-transformation ladder looms large. Most initiatives constitute incremental improvements rather than systemic transformation. Small-scale projects show promise; whole-system change remains elusive due to misaligned incentives, teacher preparation gaps, and fragile implementation ecosystems.

From a systems perspective, these patterns illustrate the critical role of feedback loops, where robust infrastructure, effective leadership, and responsive governance interact to amplify benefits, while fragile systems, in which there is misalignment among various components of the system, see benefits dissipate or produce unintended harms such as increasing inequality in opportunity to learn.

9.4 Curriculum: From Rote Content Delivery to Dynamic, Responsive Learning

Curriculum is the DNA of any education system—a repository of societal values, knowledge, and aspirations intended to shape the educational experiences of students as they interact with content and teachers. AI could, in principle, enable personalized, up-to-date, and culturally relevant curricula, bridging foundational skills with twenty-first-century competencies.

The evidence examined in this book, however, shows a more nuanced picture:

- AI Literacy in Curriculum: There are examples of AI literacy curricula in various countries, they seem to be concentrated in a few systemically strong or well-resourced settings and there is yet no evidence regarding their implementation or effectiveness.
- Foundational Literacies: Adaptive AI platforms are supporting students in gaining foundational literacies through direct experiences for students, or through support to teachers to improve their instruction. Most of the applications of AI we identified are in fact focused on strengthening those foundational literacies.
- Twenty-First Century Skills: Some innovations enable cross-disciplinary, project-based work, but most systems continue to fixate on content delivery and standardized summative assessment.
- Equity challenges are paramount: digital curricula are often imported, misaligned with local cultures, languages, or realities, risking disengagement and exclusion. The negative effects are compounded where teachers lack agency to adapt or contextualize digital content.

Transformation is possible but only where curriculum, assessment, teacher development, and system leadership co-evolve in a reinforcing loop. Slight adaptive changes, when paired with systemic realignment, can engender powerful improvements; isolated innovations cannot.

9.5 Assessment: Automating the Test, or Reimagining What Matters?

Assessment is both a mirror and an engine for learning systems. It defines what counts as success, shapes instructional practice, and allocates opportunity. AI has made substantial inroads in automating grading, enabling adaptive quizzes, and scaling formative assessment.

Yet, our review shows:

- AI Literacy: Few systems or applications help students (or teachers) assess student AI literacy skills.
- System Effectiveness: This is one of the most prevalent uses of AI, assessing student knowledge and skills to provide feedback to students and teachers, and to personalize the curriculum. Applications range from those which are student-facing, where ongoing assessment is the basis of offering automated feedback to students, and suggestions for further learning, to those that are teacher-facing, where teachers receive guidance based on assessment of the knowledge and skills of their students. All the applications we have reviewed focus on assessing the foundational competencies in the curriculum, largely literacy, writing, math, and occasionally other subjects.
- Twenty-First Century Skills: For the most part, we did not identify uses of AI to assess transversal skills such as collaboration, communication, critical thinking,

creativity and others, with the exception of a game-based learning platform (Crisis in Space) which assesses collaboration.

Most AI-driven assessment represents innovation—automating legacy practices—rather than transformation. Risks abound: amplifying inequity, entrenching "datafication," or producing accountability regimes whose metrics are misaligned with real learning.

A systems lens underscores that, unless assessment is aligned with curriculum reform and teacher professionalization, and unless AI-generated data are embedded in feedback cycles, innovative tools may introduce friction or harm.

9.6 Teacher Professional Development: Scaling Professional Growth for All

Teachers are consistently identified as the most important school-level influence on student opportunity to learn. Yet, in the Global South, teachers face chronic challenges: overcrowded classrooms, insufficient preparation, limited support, and sometimes, low societal status which translate into insufficient candidates to join the profession and limited knowledge and skills of those who do.

AI shows significant potential for scaling personalized, just-in-time professional development (PD), automated feedback, and communities of practice. As our review demonstrates:

- AI Literacy: We did not find examples of AI-enabled PD that supported teachers in developing AI knowledge and pedagogical content knowledge to support their students in becoming AI literate.
- Foundational Literacies: There are examples of AI applications that support teachers in improving their ability to teach foundational literacies. Many of these are in the form of providing just-in-time job-embedded support to teachers, for instance helping them generate lesson plans that are contextually appropriate, based on curriculum standards, or providing them with feedback on the knowledge of their students and suggestions to address specific gaps or to support personalized learning.

We did not identify AI applications that augmented the capacity of teachers to teach twenty-first century transversal skills, for instance preparing teachers to teach interdisciplinarily, or integrating socio-emotional development with academic instruction, or teaching collaboration and higher order cognitive skills.

9.7 School Organization and Management: Leadership in the Age of Data

Effective schools benefit from visionary, adaptive leadership and collaborative, distributed school organization. AI can support this through data-driven insights, predictive analytics, and smarter resource management.

Yet, as our synthesis reveals:

- AI Literacy: School leaders are only beginning to access tailored training on leveraging AI, and understanding its risks and potential for their contexts.
- Effectiveness: Tools for attendance tracking, resource allocation, and risk management can enhance operational effectiveness, yet frequently privilege administrative efficiency over instructional leadership.
- Twenty-First-Century Skills: Platforms for collaboration and networked learning among staff are emerging, but mostly in high-resource settings.

Beyond these, school leadership remains largely about human relationships. Using AI is not just about the technology, it also relies on leaders' ability to build trust, encourage teamwork, and create a school culture where teachers feel supported instead of being watched. It is also important to restore the respect and motivation of school leaders, since a loss of prestige makes it harder for them to guide schools both academically and culturally.

So far, AI has mostly brought improvements in logistics and making data more transparent, but real transformation where AI helps schools become more participatory and community-driven is still rare. Examples from Chile, Ghana, Brazil, and Uruguay show both the promise of AI to support school leadership and the ongoing challenges of fairness, adapting to local contexts, and long-term sustainability. For AI to make a real difference, policymakers must first put in place strong data systems, clear rules for governance, and reliable funding. Without these basics, AI risks being only a surface-level fix instead of driving meaningful change.

Finally, equity remains a key concern, because schools in rural or under-resourced areas often lack the technology and capacity to benefit from AI, which could leave them even further behind.

Feedback loops, the hallmark of adaptive systems, only arise where human judgment and digital analytics inform each other in a continuous, trust-based cycle.

9.8 Governance: Reimagining Accountability and Participation in the Digital Era

AI's potential to revolutionize education governance is profound: real-time data can illuminate inequities, enable targeted interventions, and, in principle, inform more democratic and inclusive policy. Yet, entrenched problems of capacity, data quality, siloed institutions, and lack of transparency persist.

Key takeaways across our review:

- AI Literacy: There is limited capacity to make sense of, question, and critically use AI-generated information among policymakers and administrators.
- Effectiveness: AI-powered dashboards enable more timely or even proactive decision-making for resource allocation or crisis response, but rarely drive bottom-up policy learning or rapid adjustment at scale.
- Twenty-First-Century Skills: Systemic support for student agency, voice, social-emotional learning, or civic engagement is rarely tracked, let alone enabled, by AI tools in conventional governance regimes.

So far, digital innovation in governance remains largely technocratic: improving planning, reporting, and compliance rather than transforming the nature of decision-making or participation. Most notably, marginalized voices risk being excluded unless participatory processes are proactively embedded and monitored.

From a systems viewpoint, small changes in information flow can have outsized effects when embedded in virtuous feedback loops, but technological fixes applied to disconnected points in the system rarely succeed.

9.9 Overarching Themes: Lessons from a Systems Perspective

Every chapter of this book affirms central systems principles:

- Initial Conditions: The impact of AI interventions is powerfully shaped by pre-existing inequalities in resource allocation including connectivity and access to devices, policy commitment, teacher capacity and infrastructure.
- Feedback Loops and Interactions: The biggest educational gains arise where AI is embedded in broader cycles of organizational learning, where data, human judgment, leadership, and community input reinforce each other. In Chap. 7, AI dashboards linked to EMIS data enable leaders to use school-level evidence for continuous instructional improvement
- Unintended Consequences: Many well-meaning innovations introduce new risks or inequities if not checked by whole-system awareness, ethics, and local adaptability.
- Nonlinearity and Emergence: Small, context-sensitive interventions, if aligned with local needs and system incentives, can produce disproportionately large positive effects. Conversely, large programs imposed without adaptation or stakeholder buy-in often fizzle or backfire. In Chap. 4, Kolibri's offline platform allowed marginalized communities to access personalized learning even with low connectivity, showing impact from context-sensitive design
- Ethics and Inclusion as Core System Properties: Sustained progress depends not only on technical prowess, but also on responsiveness to questions of justice, privacy, transparency, and cultural relevance.

9.10 Cross-Chapter Ethical Reflections

The book has surfaced a range of ethical questions that cut across domains:

- Privacy and Data Protection: The proliferation of digital data about students, teachers, and families raises questions about consent, ownership, and stewardship, especially acute in weakly regulated environments.
- Algorithmic Bias: AI systems risk encoding and amplifying inequalities unless carefully audited, localized, and held transparent to users and communities.
- Participation, Agency, and Autonomy: Educational innovation must avoid "deskilling" teachers or "datafying" students in ways that erode agency, dignity, and voice. Chapter 7 showed how participatory feedback loops (AI chatbots and sentiment analysis for collecting student/parent input) can democratize leadership if designed inclusively.
- Equity: If not guarded, AI will reinforce and widen, not bridge, the opportunity gap, privileging the already-connected and further marginalizing the invisible.
- Commercialization and the Public Good: The interests of for-profit ed-tech providers, especially in AI curriculum, assessment, and governance, may diverge from the needs of learners and communities. Chapter 4 raised risks of imported AI curricula misaligned with local languages and cultures, underscoring how commercial platforms may not serve public interests
- Sustainability: Governance must consider not only short-term gains but the lifelong trajectories of learners and the ecological consequences of educational technology.

9.11 Implications for Policymakers, Practitioners, and the Global Community

For Policymakers:

- Set the Vision: Anchor technological change to long-term policy goals: equity, foundational learning, citizenship, and well-being, not to technology for its own sake.
- Build Capacity: Invest in infrastructure, but equally in people: teachers, leaders, administrators, with the skills, confidence, and judgment to adapt and shape AI responsibly.
- Promote Inclusion: Prioritize those hardest to reach: rural, remote, marginalized learners and educators, in system designs, funding, and accountability.
- Align and Integrate: Foster coherence across curriculum, assessment, teacher development, and school organization, ensuring that digital initiatives support, not fragment, holistic change.

- Regulate and Safeguard: Enact robust frameworks for data privacy, ethical oversight, and participatory policy to keep public interest at the center of AI deployment.

For Practitioners:

- Be Critical and Creative: See AI as a tool to be shaped, not simply adopted. Question the rationale for each innovation and adapt to local contexts.
- Foster Collaborative Communities: Use digital platforms to share, reflect, and advocate, locally and across systems.
- Defend Professional Agency: Embrace new roles as designers of learning experiences within a changing digital landscape, but resist pressures to cede autonomy to opaque systems or unaligned mandates.

For AI Developers:

- Design for Diversity, Not Uniformity: Co-create solutions with schools, teachers, and communities. Prioritize language, cultural adaptation, and platform flexibility.
- Prioritize Transparency and Explainability: Build systems open to scrutiny, user feedback, and community oversight.
- Advance Open Ecosystems: Support open standards, interoperability, and local capacity-building rather than proprietary lock-in or donor-dependency models.
- Champion the Ethical Public Good: Embed equity, privacy, and human flourishing at the heart of design choices, moving beyond mere efficiency or new market capture.

For International Organizations and Philanthropy:

- Support Research and Evaluation: Fund longitudinal studies and comparative research on what works, for whom, and in what contexts.
- Model Ethical Practice: Ensure global guidance on data, AI ethics, and equitable participation sets a high bar for governments and industry alike.
- Facilitate South-South Learning: Create platforms for developing countries to share context-sensitive models and lessons outside of donor or corporate framing.

9.12 Research Frontiers and Unanswered Questions

Despite rapid progress, critical questions remain. We have outlined key questions following each chapter concerning the specific topic being addressed. Here, we outline some overarching lines of inquiry we believe are important to pursue:

- How can AI and digital tools be best leveraged for foundational and twenty-first century skills at a national scale, without deepening divides?
- What works for building AI literacy, not just technical but also ethical, civic, and creative capacities, across diverse educational realities?

- How can AI be systematically harnessed to shift education from summative accountability toward formative, personalized, holistic learning and assessment?
- What governance and regulatory models ensure AI is deployed transparently, inclusively, and with redress mechanisms for harm?
- How can we continually adapt, iterate, and learn from failures and unintended consequences of AI use in education within local systems, not just at the project or pilot level?
- What incentive and feedback structures best balance the adoption of AI based educational innovations with caution, especially when stakes and risks are distributed so unequally?

9.13 Final Thought

The challenge and promise of AI in education is, at its core, a challenge not of machines, but of human systems and values. By placing equity, participation, and ethical care at the center, and by learning to work across sectors and silos, we can shape an AI-powered educational future that delivers not just innovation, but genuine and sustainable transformation for all.

At stake is nothing less than the future character of education itself. AI and digital tools can be a force multiplier for justice, creativity, inclusion, and collective well-being, but only if actors at every level embrace the hard work of systems integration, continual ethical inquiry, and humility in the face of uncertainty.

Transformation will not come from technology alone. It requires reimagining education as an adaptive, caring, democratic endeavor, anchored in local knowledge, shaped by teachers and learners, and overseen by inclusive, accountable governance. The vital work is ongoing: to ensure that every child, in every community, has the opportunity to learn what matters, with dignity and agency, in a world of complexity and change.

Glossary

Chapter 1: Introduction

Abstract

- **Education Systems**: The complex ecology of institutions—schools, curricula, teachers, and governance mechanisms—that collectively shape learning opportunities.
- **Systems Approach**: A perspective that examines the dynamic interplay among curriculum, teachers, assessment, and broader organizational, policy, and social contexts, using ideas like feedback loops and emergence.

1.1 Purpose of the Book

- **Artificial Intelligence (AI)**: "The simulation of human intelligence by machines…with the capability to behave like humans in tasks such as communicating, memorizing, reasoning, and learning" (Martin et al., 2024).
- **Education Systems (scope in this book)**: Institutions designed and funded to help learners develop knowledge and skills, focusing on compulsory education (pre-school, elementary, secondary).
- **Curriculum Goals**:
  - **Intended goals**: what should be learned.
  - **Achieved goals**: what is actually learned.
- **Effectiveness (of education systems)**: Increasing students' opportunity to learn what is intended.
- **Relevance (of education systems)**: Increasing students' opportunity to learn a curriculum that advances their life circumstances in a changing world.

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- **AI Literacy**: A subset of relevant skills needed to operate in an AI-shaped world.
- **Educational Improvement vs. Educational Transformation**:
  - **Improvement**: any support to teaching/learning.
  - **Transformation**: solving the most important problems at scale in sustainable ways.

1.2 Why this Book on Education and Artificial Intelligence?

- **Co-Intelligence**: Humans working in partnership with AI-enabled platforms.
- **Knowledge-Based Jobs**: Occupations primarily relying on intellectual expertise rather than manual skill.
- **Human Skills in an AI World**: Collaboration, interpersonal, and ethical/moral reasoning skills whose value rises as AI transforms workplaces.

1.3 Why Do We Focus on the Global South?

- **Global South**: Countries (most of Africa, Latin America, the Caribbean, Asia, and Oceania, excluding Australia and New Zealand) with lower resources per capita/student and home to ~85% of the world's population and ~90% of people under 18.
- **North–South Divide**: The Brandt Report (1980) framing of a wealthier "North" and poorer "South."

1.4 Thinking Systemically

- **Education System (organizational definition)**: The infrastructure—policies, institutions, structures, processes, resources—created to transmit valued knowledge, skills, and values across generations.
- **Complexity Science**: Study of systems characterized by non-linearity, sensitivity to initial conditions, and feedback loops.
- **Emergence**: Organized, complex behavior arising from simple local interactions without central control.
- **Feedback Loops**: Positive/negative cycles in system interactions that amplify or stabilize effects.
- **Distributed Control**: No single part governs the whole; control and information are spread across the system.
- **Curriculum**: The set of educational goals guiding learning, with scope and sequence translating goals into a progression.

1.5 What Is Artificial Intelligence in Education?

- **Machine Learning (ML)**: Algorithms that learn from data and improve over time without explicit programming.
- **Natural Language Processing (NLP)**: Techniques enabling machines to interpret and generate human language.
- **Computer Vision**: Techniques enabling software to interpret visual information.
- **Narrow (Weak) AI**: AI designed for specific tasks (e.g., recommending assignments, classifying responses).
- **General (Strong) AI**: A theoretical AI with human-like reasoning, abstraction, and cross-domain learning.

1.6 A Systems Approach to Studying the Role of AI in Education

- **Human-Centered AI (systemic view)**: Considering effects not only on direct users (teachers/students) but also on classrooms, communities, and society.
- **Second-Order Effects**: Indirect or ripple impacts that arise from feedback loops and interactions (e.g., admin automation freeing time for instructional leadership).

1.7 Student Learning: The Core of Education

- **Opportunity to Learn**: A system's capacity to provide meaningful learning experiences to students.
- **Public Education**: State-supported, universal systems intended to serve social, economic, and civic goals.
- **Progressive Education**: Child-centered, holistic, experiential learning tradition associated with Pestalozzi.
- **Monitorial System**: Lancaster's structured, low-cost method where advanced students teach peers under a tutor's supervision
- **Scientific Management (Taylorism) in Education**: School organization influenced by industrial efficiency—standardized curriculum, schedules, and processes.

1.8 How Can AI Improve the Opportunity to Learn?

1.8.1 How Can AI Literacy Be Developed?

- **Competency Framework for AI Literacy**: A structure that includes technical skills plus critical thinking, problem-solving, and ethical reflection (privacy, bias, social impact).

- **Project-Based Learning (for AI literacy)**: Hands-on, practical work to build procedural and conceptual understanding of AI.

1.8.3 What Makes Us Uniquely Human? Mitigating Workforce Displacement Risk

- **Workforce Displacement**: Job loss risks from AI's replication of routine/analytical tasks.
- **ADDIE Model**: Instructional design framework—Analysis, Design, Development, Implementation, Evaluation—for building effective reskilling.
- **Universal Basic Income (UBI)**: Unconditional income support proposed as a buffer during AI-driven labor transitions.

Chapter 2: Challenges and Opportunities of Education in the Global South

Abstract

- **Global South**: Countries in Africa, Asia, Latin America and the Caribbean, and parts of Oceania (excluding Australia/New Zealand) that collectively enroll most of the world's children yet face lower per-capita resources and persistent inequalities.
- **Systemic Enablers**: Policy, governance, funding, community, and institutional conditions that allow education systems to function and improve toward equitable learning.

2.1 Access: Spectacular Gains, Uneven Realities

- **Enrollment Rate**: Share of children of a given age/level who are enrolled in school.
- **Meaningful Access**: Access conceived beyond initial enrollment to include regular attendance, safety, inclusion, learning support, and completion—especially for marginalized learners.
- **Early Childhood Education (ECE)**: The pre-primary stage foundational to brain development and later learning, where access remains highly unequal in low-income contexts.

2.2 Learning Outcomes: The Global Learning Crisis

- **Learning Poverty**: Percentage of 10-year-olds unable to read and understand a short, age-appropriate text.
- **Foundational Learning**: Mastery of basic literacy and numeracy—especially in the early grades—as a prerequisite for later achievement.
- **Mother-Tongue Instruction**: Teaching in learners' first language in early years to strengthen comprehension and outcomes.

2.3 Equity and the Web of Exclusions

- **Web of Exclusions**: Intersecting barriers (poverty, gender, disability, language, ethnicity, conflict) that systematically marginalize learners.
- **Gender Parity (in Education)**: The degree to which girls and boys participate and achieve at comparable rates across levels and roles (enrollment, learning, leadership, fields like STEM).
- **Inclusive Education**: Educating all learners together with the supports needed to ensure equitable participation and outcomes.
- **Disability–Poverty Cycle**: A mutually reinforcing dynamic in which poverty increases disability risk and impact, while disability increases the likelihood of persistent poverty and educational exclusion.
- **Education in Conflict**: Schooling disrupted or endangered by violence, displacement, or attacks on education, leading to prolonged exclusion and trauma.

2.4 The Teacher Workforce: Professionalization and Regression

- **Qualified Teacher**: A teacher meeting nationally defined minimum training/credential standards—shares of which have declined in some regions.
- **Teacher Professional Development (TPD)**: Ongoing, job-embedded learning to strengthen instructional practice and student learning at scale.

2.5 Financing, Poverty, and Inequality

- **Outcomes Fund (Outcomes-Based Financing)**: A mechanism that pools public/private funding and pays providers when independently verified learning or employment results are achieved, aiming to improve efficiency and equity.
- **Debt Service Crowding-Out**: Public debt payments reducing fiscal space for education investments, especially in low-income countries.

2.6 Relevant Curriculum

- **Relevant Curriculum**: Programs of study connected to learners' lives, languages, cultures, and labor-market realities (including informal economies).
- **Cultural Relevance**: Alignment of content and pedagogy with learners' identities, languages, and community knowledge systems.
- **Informal Apprenticeship**: Skills training through workplace practice under a skilled worker outside formal certification structures.

2.7 Systemic Disruptions: Migration, and Climate Change

- **Education in Emergencies**: Teaching and learning during crises (conflict, displacement, pandemics, disasters) with measures to protect continuity and equity.
- **Climate Education Gap**: The shortfall in laws, curricula, and classroom time devoted to climate change and biodiversity education relative to escalating risks.
- **Resilient Education Systems**: Systems designed to anticipate, absorb, adapt to, and recover from shocks while safeguarding learning.
- **Information/Digital Risk**: Threats (mis/disinformation, cyberattacks, unsafe AI use) that erode trust and require strengthened digital safety and data governance in schools.

2.8 The Digital Divide and the Role of Technology

- **Digital Divide**: Inequalities in access to electricity, connectivity, devices, and digital skills that shape who benefits from EdTech/AI.
- **Low-Connectivity EdTech**: Tools and delivery models (e.g., mobile messaging apps, offline-first designs) that function with limited bandwidth and intermittent access.
- **Localization of EdTech**: Adapting digital/AI content to local languages, cultures, curricula, and constraints through community and educator input.

2.9 Towards a New Future for Education (OECD Scenarios)

- **Schooling Extended**: Public schools remain central and are strengthened by cooperation, infrastructure, and pedagogy (AI supports teachers and personalization).
- **Education Outsourced**: Learning shifts toward privatized, platform-driven solutions and micro-credentials, with equity risks where public systems are weak.

- **Schools as Learning Hubs**: Schools integrate community services and lifelong learning; AI helps coordinate responses to local needs and engage families.
- **Learn-as-You-Go**: Continuous, tech-embedded learning replaces formal schooling, with profound equity, privacy, and social-learning implications.

Chapter 3: Students, Learning, Classrooms and Schools

3.1 Introduction

- **Carroll Model of School Learning**: A framework by John B. Carroll (1963) proposing that learning is a function of engaged learning time relative to time needed. Five key variables:

  1. **Aptitude**—time needed to learn content.
  2. **Opportunity to Learn**—actual time allocated.
  3. **Perseverance**—time a student actually spends learning.
  4. **Quality of Instruction**—effectiveness of teaching.
  5. **Ability to Understand Instruction**—degree to which students comprehend teaching.

     Corollaries: Given enough time, most students can master content; differences in learning reflect opportunity, not innate differences.

3.2 Who Are the Students and What Challenges Do They Face?

- **Heterogeneity (in student body)**: Diversity of learners' socio-economic conditions, cultural backgrounds, prior knowledge, language abilities, and interests resulting from expanded access.
- **Whole-Class Instruction**: A teacher-centered pedagogy where the teacher lectures to all students, limiting opportunities for feedback, engagement, and personalization.
- **Personalization (of learning)**: Designing instruction to accommodate individual students' needs, interests, and abilities, requiring continuous information about learners and adaptive teaching strategies.
- **Global Learning Crisis**: The widespread failure of education systems to ensure students achieve even foundational skills, due to systemic rigidities and lack of personalization.

3.3 Can Artificial Intelligence Address These Shortcomings?

- **Adaptive Learning Platforms**: AI-powered systems that analyze student responses, pace, and knowledge gaps to dynamically adjust instruction, feedback, and curriculum sequencing.
- **AI for Accessibility**: Tools like speech-to-text, automatic translation, and personalized content adaptation enabling students with disabilities to access learning.
- **AI Unplugged**: An approach (developed by Seiji Isotani) where teachers use low-tech AI platforms—for example, uploading photos of student work for AI grading—allowing equitable feedback without requiring student devices or connectivity.

3.4 What Does the Evidence Say?

- **Intelligent Tutoring Systems (ITS)**: AI applications that deliver step-by-step, adaptive support, assess mastery, and provide targeted feedback, especially in subjects like mathematics.
- **AI Literacy in Schools**: Initiatives to build students' understanding of AI's concepts, uses, and societal impacts—often through extracurricular activities (workshops, camps, electives) rather than integrated curricula.
- **Teacher Preparedness (re: AI)**: Teachers' readiness to adopt AI tools, including their confidence, skills, and perceptions of AI's benefits or risks.
- **Quality Assurance in AI Education**: Processes ensuring AI-generated content is educationally sound and pedagogically aligned, avoiding superficial learning or teacher deskilling.

3.4.1 Personalized and Adaptive Learning

- **Personalized Curriculum Platforms (examples)**:
  - *Letrus* (Brazil): AI analyzes student writing and provides feedback on grammar, coherence, and style.
  - *Geekie* (Brazil): Personalized assessments and study exercises.
  - *Flex-Flix* (Argentina): AI-supported streaming tied to national curriculum with interactive assistance.
  - *KHistoriA* (Brazil): Allows students to converse with historical figures via AI.
  - *Plataforma AZ* (Brazil): Generative AI creating personalized study plans and feedback for 400+ schools.
  - *MATHia* (US): Cognitive tutor in mathematics diagnosing misconceptions and providing feedback.

  - *Snappet* (Netherlands/Spain): Adaptive learning for math and language in primary schools, offering dashboards for teachers.
  - *Beekee Box/Hub*: Offline digital classrooms creating local networks for interactive learning without internet.

3.5 Conclusion and Policy Takeaways

- **Foundational Literacies (via AI)**: AI's potential to improve basic literacy and numeracy through adaptive platforms, though most efforts are still at pilot stage.
- **Twenty-First Century Skills (via AI)**: Problem-solving, creativity, and collaboration supported through project-based AI applications, though not yet mainstreamed in curricula.
- **Innovation vs. Transformation**: Distinction between AI innovations that supplement current methods versus systemic transformations that fundamentally reconfigure learning.
- **Digital Divide (AI context)**: The risk that AI's benefits accrue disproportionately to privileged students, deepening inequality.
- **Algorithmic Bias in Education**: Risk that AI systems reproduce existing inequalities if trained on biased or limited data.
- **Transparency and Explainability**: The principle that AI-driven decisions in education must be understandable to students, teachers, and parents to build trust and preserve agency.

Chapter 4: AI and Curriculum

4.1 Introduction

- **Curriculum**: A multi-layered construct described as the "DNA of the education system" (UNESCO, 2023a). It comprises three layers:
  - **Intended Curriculum**: Formal goals, objectives, and content prescribed by authorities (sometimes highly prescriptive, sometimes only broad standards).
  - **Implemented Curriculum**: What actually occurs in classrooms, shaped by teachers, pedagogy, and resources.
  - **Achieved Curriculum**: Tangible learning outcomes and competencies demonstrated by students.

4.1.1 Knowledge-Based Curriculum, Foundational Skills and Transferable Skills

- **Knowledge-Based Curriculum**: A traditional curriculum design emphasizing broad content coverage and rote memorization, often at the expense of deep understanding and transferable skills.
- **Transferable Skills (Twenty-First-Century Skills)**: Competencies like critical thinking, problem-solving, creativity, communication, and collaboration, necessary for adaptability, lifelong learning, and future work.
- **Zone of Proximal Development**: The range of learning tasks that are just beyond what a learner can do independently but achievable with guidance; overcrowded curricula often exceed this zone.

4.1.2 Challenges in Vertical and Horizontal Curriculum Coherence

- **Curriculum Coherence**: The alignment of curriculum elements to support cumulative learning.
  - **Vertical Coherence**: Logical sequencing of content and skills across grade levels for cumulative progression.
  - **Horizontal Coherence**: Integration and connection of concepts and skills across different subjects within the same grade.

4.1.3 Misalignment of Curriculum, Pedagogy, and Assessment

- **Curriculum–Pedagogy–Assessment Alignment**: The systemic requirement that what is taught (curriculum), how it is taught (pedagogy), and how it is measured (assessment) must be consistent to support effective learning.
- **Teaching to the Test**: A practice where instruction is narrowly aligned with what is tested; problematic when exams emphasize recall over higher-order competencies.

4.1.4 Alignment Between Curriculum and Context

- **Differentiated Instruction**: Tailoring content, processes, and products to meet diverse student needs (e.g., Universal Design for Learning—UDL).
- **Competency-Based Learning**: An approach emphasizing what students can *do* with knowledge, prioritizing mastery of skills over time spent.

4.2 AI and the Curriculum

AI as a Curriculum Tool

- **AI-Powered Curriculum Adaptation**: AI assisting teachers or ministries to modify curricula by simplifying, extending, or personalizing content to suit learners' needs.
- **AI for Localization & Contextualization**: AI generating culturally relevant materials in local languages, addressing resource scarcity.
- **AI-Powered Adaptive Learning**: Delivering individualized, scaffolded learning pathways to manage heterogeneity.
- **AI-Powered Curriculum Analytics**: Using aggregated student data to detect systemic gaps and create continuous feedback loops for curriculum reform.

UNESCO's Nine Areas of AI Curriculum Content

- **AI Curriculum Domains** (UNESCO, 2022): Algorithms/programming, data literacy, contextual problem-solving, ethics of AI, societal implications, applications in other domains, understanding/using AI techniques, understanding/using AI technologies, and developing AI technologies.

4.2.1 Teaching About AI (National Models)

- **China's Tiered AI Curriculum**: A spiral system across primary–high school emphasizing innovation, ethics, and "teacher-student-machine" collaboration.
- **UAE AI Curriculum**: Integration of AI from kindergarten to grade 12, embedding ethics and applications at age-appropriate levels.
- **Uruguay Ceibal Framework**: A pedagogical model organized around "What is AI?", "How does it work?", and "What can it do?", emphasizing ethics and computational thinking.
- **India YUVAi Program**: Project-based national initiative for grades 8–12, focusing on responsible AI use in real-world themes like agriculture, health, and education.
- **Estonia AI Leap Initiative**: National pilot providing AI applications to students and teachers, combining personalization, teacher support, and policy-driven integration.

4.2.2 AI in Curriculum Delivery and Design

- **AI-Powered Lesson Planning**: Tools (e.g., Nova Escola's ANE chatbot in Brazil) generating curriculum-aligned lesson plans to reduce teacher workload.

- **AI for Textbook Development**: Projects (e.g., GPE KIX STEPS in Benin, Cameroon, DRC) using AI to draft, translate, and contextualize STEM textbooks.
- **AI Textbooks**: Digital, adaptive textbooks (e.g., South Korea) providing personalized learning and bridging achievement gaps.

4.2.3 AI for Personalization and Transferable Skills

- **General-Purpose Generative AI for Education**: Teachers' use of tools like ChatGPT or Copilot to create differentiated lessons, quizzes, and stories.
- **Equivalent Years of Schooling (EYOS)**: A metric comparing learning gains from interventions (e.g., Edo State pilot in Nigeria) to those from standard years of schooling.
- **Plu AI Assistant (Brazil)**: An AI tool supporting both teachers (lesson plans, activities) and students (study plans, summaries).
- **Kolibri**: An offline-first platform enabling curriculum alignment and personalized learning in low-connectivity environments.
- **RobotsMali**: AI-generated localized children's books in Bambara, addressing early literacy in local languages.
- **AI for Inclusive Curriculum (Maseno University, Kenya)**: An AI tool translating English into Kenyan Sign Language, improving curriculum accessibility for Deaf learners.

4.3 Conclusions (Key Systemic Concepts)

- **Holistic AI Literacy**: A broad approach to AI education combining technical knowledge with ethics, societal impact, and critical thinking.
- **Cross-Curricular Integration of AI**: Embedding AI concepts across subjects rather than as standalone content, to avoid overcrowding curricula.
- **Curriculum Intelligence Hubs**: A proposed system-level use of anonymized student data to identify patterns, inform curriculum reform, and support evidence-based policymaking.

Chapter 5: Assessment and AI

5.2 The Assessment Paradox: Problems, Context, and Challenges

- **Summative Assessment**: High-stakes, accountability-driven testing used to judge student progression, teacher effectiveness, or system performance (e.g., O levels, A levels, matriculation exams).

- **Formative Assessment**: "Assessment for learning"—continuous evidence-gathering to provide feedback that modifies teaching and supports student progress (introduced by Scriven and Bloom in the late 1960s).
- **High-Stakes Exams**: Examinations with major consequences for student progression, scholarships, and life opportunities; often narrow the curriculum toward rote memorization.
- **Curriculum Narrowing**: The phenomenon where teachers focus only on tested content, neglecting untested subjects or deeper learning.
- **Assessment for Learning vs. Assessment of Learning**: Contrast between formative, feedback-oriented assessments and summative, judgment-oriented assessments.
- **Measurement Crisis**: The difficulty of assessing complex, "uniquely human" skills (collaboration, creativity, critical thinking) with traditional instruments, especially across diverse cultural contexts.

5.3 Assessment Reimagined: What AI Could Do

- **AI-Powered Formative Feedback**: Embedding AI in learning platforms to give real-time, personalized support and hints.
- **AI-Powered Portfolio Assessment**: Using AI to analyze a student's accumulated work (essays, reports, projects) to create a holistic competency profile.
- **AI-Analyzed Simulations**: Game-based or virtual environments where AI measures collaboration and problem-solving by analyzing interactions and communication patterns.
- **Creative Process Analysis**: Assessing critical thinking by tracking a student's interaction with generative tools—prompts, drafts, and iterations—rather than just final outputs.
- **Culturally and Linguistically Adaptive AI Assessment**: Generative AI creating test items embedded in local languages and contexts, making them more valid and fair.

5.4 Assessment and AI in Practice: What AI Is Doing

- **Automated Grading Systems**: AI used to score multiple-choice or open-ended tasks quickly and consistently, reducing teacher workload.
- **AI-Powered Proctoring**: Remote monitoring of students during online exams using webcams and algorithms to detect cheating; raises privacy and ethics concerns.
- **Computerized Adaptive Testing (CAT)**: Assessments that adjust item difficulty in real time based on student responses, providing more precise measures.

- **Multistage Adaptive Testing (MSAT)**: A variant of CAT where students move through sets of preassembled test modules of increasing or decreasing difficulty.
- **Artificial Intelligence in Education Unplugged (AIED Unplugged)**: Approaches that allow AI-supported assessment (e.g., essay grading) even in low-connectivity contexts by syncing data intermittently.
- **Game-Based Assessment**: Use of AI-driven games (e.g., ACTNext's *Crisis in Space*) to measure collaboration, socio-emotional skills, or critical thinking.
- **Equivalent Years of Schooling (EYOS)**: A metric comparing learning gains from interventions (like AI tutoring) to the progress expected from traditional years of schooling.

5.7 Conclusion: Charting a Course for the Future of Assessment

- **Cognitive Mirrors**: AI tools envisioned to help students reflect on their own thought processes, fostering metacognition and self-regulation.
- **Assessment as Learning**: A transformative model where assessment itself becomes a learning process, not just a measurement tool.

Chapter 6: AI and Teacher Development

6.2 Teacher Professional Development Challenges

- **Teacher Professional Development (TPD)**: A career-long continuum including initial preparation, induction, in-service learning, mentoring, and leadership opportunities to build and sustain teaching quality.
- **Pedagogical Content Knowledge (PCK)**: Knowledge integrating pedagogy and subject matter expertise, enabling teachers to explain concepts effectively.
- **Collaborative Professionalism**: A culture in which teachers engage in sustained, collegial, and job-embedded learning, co-constructing knowledge and practices.
- **Three-Strand AI Literacy for Teachers**:
  1. **Teaching about AI**—imparting knowledge of core AI concepts and societal implications.
  2. **Teaching with AI**—using AI tools to enhance instruction.
  3. **Teaching against AI**—critically engaging with AI's limitations, biases, and inappropriate uses.

6.3 How Could AI Help Teachers Develop Pedagogical Knowledge and Skills?

6.3.1 Lesson Planning and Differentiated Instruction

- **Pedagogical Prompt Engineering**: Teachers' skill in crafting prompts that elicit high-quality, pedagogically sound, contextually relevant AI outputs.
- **Differentiated Instruction with AI**: Use of AI tools (e.g., Diffit, Eduaide.AI) to generate tiered tasks and leveled materials tailored to students' varied readiness levels.

6.3.2 Instructional Coaching

- **AI-Supported Instructional Coaching**: AI systems analyzing classroom data (dialogue, recordings) to provide personalized, context-sensitive feedback and help teachers improve their practice.

6.3.3 Simulations

- **AI-Powered Teaching Simulations**: Interactive environments with AI-driven student avatars simulating diverse learner profiles, enabling teachers to rehearse strategies in risk-free settings.

6.3.4 Deconstructing Expertise

- **AI-Augmented Expertise Deconstruction**: Tools analyzing video/audio of master teachers to tag and annotate effective pedagogical moves, making tacit expertise visible to novices.

6.3.5 Deepening Teacher Content Knowledge

- **Socratic Sparring Partner (AI Role)**: AI acting as a dialogue partner, asking probing questions to challenge teachers' conceptual understanding and refine their explanations.

6.3.6 Frameworks for Teacher Knowledge and AI

- **TPACK (Technological Pedagogical Content Knowledge)**: Framework describing what teachers need to integrate technology effectively (tech + pedagogy + content).

- **AIPACK (Artificial Intelligence Pedagogical Content Knowledge)**: Extension of TPACK focusing on teachers' knowledge to use AI ethically and pedagogically.
- **PACK (Pedagogical AI Content Knowledge)**: Proposed framework describing what *AI tools themselves* must be imbued with (pedagogical + content knowledge relevant to local curricula).

6.4 How Could AI Help Teachers with Administrative Tasks?

- **AI Administrative Automation**: AI systems reducing teacher workload by managing attendance, grading short-answer tasks, drafting reports, or generating communications.

6.5 Fostering Collaborative Professionalism

- **Professional Learning Communities (PLCs)**: Teacher groups focused on shared reflection, resource exchange, and pedagogical improvement.
- **AI-Enabled PLCs**: Platforms (e.g., Disco, Playlab.ai, Knowt Agenda Generator) leveraging AI to streamline collaboration, summarize discussions, and generate agendas.

6.7 Conclusion and Takeaways

- **AI Pedagogical Content Knowledge (AI-PCK)**: A proposed teacher competency involving subject-specific, ethical, and pedagogical uses of AI.
- **Cognitive Dependency Risk**: Concern that teachers may over-rely on AI tools, weakening their independent professional judgment and creativity.
- **Teacher Agency**: Teachers' capacity to make informed, professional decisions; critical to ensuring AI augments rather than replaces teacher autonomy.

Chapter 7: AI and School Organization and Management

7.1 The Problems: School Leadership and School Organization in the Global South

- **Grammar of Schooling**: The persistent organizational patterns of mass education (rigid timetables, age-graded classes, subject silos) that constrain personalization, teacher collaboration, and innovation.

- **School Effectiveness (school-level)**: The extent to which a school attains educational goals given its context and resources; linked to instructional leadership, school climate, and progress monitoring.
- **Instructional Leadership (role focus)**: Leadership centered on improving teaching and learning (supporting teacher development, engaging families, guiding school improvement), often hampered by administrative overload.

7.2 How Can AI Support more Effective, Empowered, Empowering and Networked School Leadership?

- **Networked School Leadership**: Using AI-supported platforms to connect schools, surface similar challenges, and enable collaborative problem-solving across sites.
- **Adaptive Leadership Dashboards**: AI tools that synthesize attendance, learning, and behavior data into actionable, real-time insights for school leaders.
- **Participatory Feedback Loops**: Chatbots, automated surveys, and sentiment analysis that gather and summarize perspectives from teachers, students, and parents to inform shared decision-making.
- **Data Literacy for Leaders**: The capacity to interpret data ethically and accurately to guide equity-focused decisions; strengthened by AI but dependent on training and context.

7.3 What Is AI Already Doing In Support Of Better School Leadership? Current Use Cases and Research

- **Early Warning Systems (Dropout Risk)**: Machine-learning models that flag students at risk by combining attendance, performance, and contextual indicators to prompt timely interventions.
- **EMIS-Linked Analytics**: Integrations that connect AI dashboards to national Education Management Information Systems to shift from reactive reporting to proactive, system-level improvement.
- **Resource Optimization**: AI matching of teachers, students, and materials to needs (e.g., teacher placement, balanced enrollment, procurement forecasting) to reduce inequity and inefficiency.
- **Data Wise Improvement Cycle (with AI)**: An eight-step, collaborative inquiry process enhanced by AI dashboards to accelerate evidence use and instructional improvement.
- **Leadership Transformation**: Reallocation of leaders' time from paperwork to pedagogy as AI streamlines operations and strengthens communication with staff and families.

7.5 Ethical Questions and Concerns

- **Power Dynamics and Local Agency**: Risk that centrally controlled AI increases top-down monitoring, limiting professional judgment and school-level adaptation.
- **Cost and Accessibility**: Ongoing infrastructure, maintenance, and training costs that can exclude under-resourced schools unless solutions are designed for affordability and local capacity.
- **Inclusivity and Participation**: Ensuring AI augments, rather than displaces, human relationships and democratic school governance by intentionally including diverse stakeholders.

Chapter 8: AI and Education Governance

8.1 Introduction

- **Education Governance**: The structures, rules, and processes within education systems through which decisions are made, priorities set, resources allocated, and programs implemented, monitored, and evaluated.
- **Governance of AI in Education (vs. AI in Governance)**: Distinction between (a) regulating AI use in education (ethical frameworks, transparency, bias prevention) and (b) using AI to improve how education systems themselves are governed.
- **UNESCO Recommendation on the Ethics of AI (2021)**: An international framework setting principles such as transparency, accountability, inclusiveness, and human oversight for AI use in education.

8.2 The Problem: Governing a Complex System

8.2.1 Accountability

- **Accountability (in education governance)**: The process of accepting responsibility for the consequences of decisions and actions, especially regarding student learning, resource allocation, and teacher performance.
- **Forms of Accountability (Yan, 2019)**:
  1. **Choice and Competition**—e.g., vouchers.
  2. **Autonomy and Participation**—e.g., decentralization, school-based management.
  3. **Threat**—e.g., sanctions linked to inspections or test results.

- **Compliance vs. Improvement Accountability**: The distinction between accountability used to enforce compliance and accountability used to drive learning and system improvement.

8.2.2 Capacity

- **Capacity (governance)**: The resources, competencies, and capabilities required for actors across levels (individual, organizational, systemic) to perform governance functions effectively.
- **Policy Capacity Dimensions** (Wu et al., 2015): Analytical, operational, and political competencies necessary for effective governance.

8.2.3 Use of Data and Information

- **Policy–Practice Gap**: The disconnect between policy intentions and real-world implementation (e.g., during COVID-19, 90% of Sub-Saharan African countries adopted distance learning policies but <30% of households received it).
- **User-Centric Data Systems**: Integrated, real-time, accessible, and easy-to-understand data platforms designed to improve decision-making and communication across education levels.

8.2.4 Resource Management and Allocation

- **Resource Allocation (governance)**: Distribution of finances, personnel, and infrastructure within education systems to maximize learning outcomes; often suboptimal due to inefficiencies or misaligned priorities.

8.3 What AI Could Do: Enhancing Education Governance

- **Natural Language Processing (NLP)**: AI techniques enabling policymakers to interact with data systems using everyday language instead of technical programming.
- **Machine Learning (ML) for Governance**: Algorithms analyzing large datasets, forecasting trends, and optimizing multi-objective decisions in resource allocation and planning.
- **Human-in-the-Loop Oversight**: Role of human judgment as editor/manager of AI outputs to ensure accuracy, fairness, and logic before decisions are implemented.

8.4 What AI Is Doing to Improve Governance

8.4.1 Resource Allocation

- **Priority-Based Budgeting (AI-supported)**: Governance approach where AI analyzes spending/program data to identify patterns and align resources with priorities.
- **AI Matching Algorithms (Teacher Placement)**: Tools used to improve equitable teacher distribution by matching teacher qualifications, location preferences, and school needs.

8.4.2 Strategic Planning

- **Skills Needs Compass (Finland)**: AI-powered labor market forecasting tool aligning education with future workforce demands.
- **School-Effect Indicator (São Paulo, Brazil)**: AI-based measure comparing expected vs. actual student performance, controlling for socioeconomic factors, to identify schools' "value-add."

8.4.3 Monitoring and Evaluation

- **Citizen Feedback Platforms (e.g., GoVocal, Engage Stirling)**: AI-enhanced systems that collect, analyze, and visualize community input for education policy design and monitoring.
- **Automated Service Request Management**: NLP-based classification of citizen or stakeholder requests to speed up response times (e.g., Uruguay's AGESIC system).

8.5 Conclusion (Key Takeaways and Ethics)

8.5.1 Main Takeaways

- **Innovation vs. Transformation in Governance**: Most AI uses so far provide incremental improvements in data flows and analytics; true transformation (distributed, participatory, adaptive governance) is still rare.

8.5.3 Ethical Questions

- **Bias and Accountability in Governance**: The risk that AI obscures or amplifies inequalities unless tools are transparent, regularly audited, and coupled with fairness frameworks (e.g., IBM's AIF360).
- **Commercialization Risk**: Tensions between public interest in governance and private companies' proprietary algorithms and commercial incentives.

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