Empowering Afghan Girls and Women: Artificial Intelligence Education Model

A Policy Paper

By Abdullah Azizi
APL Affiliate

Afghanistan Policy Lab
School of Public and International Affairs
Princeton University
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AFGHANISTAN POLICY LAB

Abstract

According to UN Women (2025), Afghan girls and women achieve only 17.3% of their full potential. This constrained ecosystem for Afghan girls and women has been further limited by the ban on girls' secondary education and restrictions on women's employment. While the potential of the Fourth and Fifth Industrial Revolutions (4IR and 5IR) could help create an enabling environment, the current education system suffers from outdated curricula and pedagogical approaches that are not aligned with the requirements of 4IR, 5IR, and future skills for tangible economic returns. Afghanistan also struggles with a learning poverty rate of 93% (UNESCO & UNICEF, 2025), teacher shortages, and internet connectivity. Consequently, the current initiatives focus less on bridging the gap between education and the skills required for future employment.

To address these challenges, this study employs an in-depth case study analysis to examine five AI education models using a problem-solution and evaluation framework. Furthermore, this study adopts a process-tracing method to examine the causal mechanisms of successful interventions. This approach may help produce replicable strategies that could help a paradigm shift in the Afghan education system and inform the development of an AI education model tailored to the Afghan context.

The results of this study indicate that the current informal initiatives in Afghanistan have successfully digitized the existing school curricula and provided limited AI-based support through WhatsApp. However, they fail to provide a full-scale, offline AI mentorship model. Open-source technologies and Edge AI, using a Raspberry Pi for a local, offline AI setup, demonstrate their potential for offline operation and offer a cost-effective option for developing a full-scale offline mentorship AI model tailored to the needs of Afghan girls and women.

Finally, the current low-performing education system in Afghanistan cannot be resolved solely by digitization; a paradigm shift is necessary in both the development of new curricula and pedagogical approaches for the Afghan education system. This shift must not only link education to the 4IR and 5IR and to the labor market but also focus on preparing students for future employment by aligning learning with the skills of the future. By connecting education to tangible economic returns, this model may enable Afghan women to achieve self-sufficiency and independence in a rapidly changing world.

Contents

Section 1: Introduction

According to UN Women (2025), "nearly eight out of ten young Afghan women are excluded from education, jobs, and training in Afghanistan". In 2024, Afghanistan scored 0.173 on the Women's Empowerment Index (WEI) and 0.237 on the Global Gender Parity Index (GGPI). Translating the WEI into practical development terms, Afghan women, on average, reach only 17.3% of their potential in exercising their rights and freedoms, compared to 60.7% for women globally. The GGPI score indicates that the gender gap in Afghanistan is 76.3%. In other words, Afghan women attain only 23.7% of what Afghan men achieve in human development dimensions, compared to 72.1% globally for women. These inequalities are further exacerbated by the ban on girls' education beyond grade six and the restrictions on women's employment.

Despite these disparities and the unjust conditions for Afghan girls and women, which directly violate their fundamental human rights, the Fourth and Fifth Industrial Revolutions (4IR and 5IR) hold significant potential to correct this course. Leveraging these opportunities could enable Afghan girls and women to bridge the existing gap.

However, to leverage these future opportunities and help Afghan girls, women, and society as a whole to achieve self-sufficiency, the following systemic challenges must be addressed:

1. Outdated schooling curricula and pedagogical approaches that fail to link education to the skills required for future employment (the education-to-employment skills gap).
2. Learning poverty: 93% of students in Afghanistan are unable to read and comprehend text by the end of primary school (UNESCO & UNICEF, 2025).
3. Shortages of trained teachers, particularly female teachers.
4. Weak assessment and monitoring systems.

Artificial Intelligence (AI) and digital technology, combined with a forward-looking education model that links learning to 4IR, 5IR, and future employment opportunities, can help address these challenges and may enable Afghan girls and women to realize their full potential. By aligning future skills with measurable economic returns, these technologies will enable Afghan girls and women to achieve self-sufficiency and independence.

According to the World Economic Forum (2023), one of the major problems hindering the effective development of "future-ready" skills is not only the lack of conceptualization and identification of the skills required for the future, but also the way those skills and capabilities are developed and acquired. Suganya (2017) suggests that the digital divide and inequality are so widespread that roughly 4 billion people still lack internet access. This digital divide further increases inequality and poverty in an era of rapid technological change. Furthermore, the challenge is not only providing access but also ensuring that digital technology empowers these women and girls to expand their choices for a life they value and have reason to pursue (Choudhary & Bansal, 2022).

To address these challenges and equip Afghan girls and women with future skill sets, this study is guided by the following questions: (1) What makes the education system high performing in the 4IR and 5IR era? (2) What skills are required to thrive in the 4IR and 5IR era – linking education

to skills? (3) What are the current systemic challenges and gaps in Afghan girls' education, and to what extent do current initiatives address or fail to address these challenges and gaps? (4) How can an evidence-based AI education model be developed for the Afghan context to empower Afghan girls?

Within this context, this study aims to contribute to the development of systematic and replicable knowledge by employing a process-tracing method and an in-depth case study approach. The case study framework is structured around problem-solution-outcome evaluation to examine how similar problems were resolved. This approach will enable the study to produce step-by-step, useful, and replicable knowledge. Such knowledge can inform the design of an AI learning platform to equip Afghan girls and women with the skills necessary to thrive in the eras of 4IR and 5IR.

In the first step, this study conducts an in-depth analysis of the relationship between 4IR, 5IR, education, and employment. It examines how these industrial revolutions transform markets and opportunities, and which educational model, particularly the education-to-employment model, is best suited to prepare students with the skill sets required to thrive in this fast-paced, evolving era.

In the second step, the research examines how AI is integrated into educational settings to produce step-by-step knowledge that allows educators to improve education outcomes. A World Bank study found that a six-week after-school pilot program in nine Nigerian schools powered by generative AI (Microsoft Co-Polit) delivered learning gains equivalent to 2 years of traditional schooling. Furthermore, a hundred-dollar investment delivered 3.2 equivalent years of schooling (De Simone, et al., 2025). This study confirms both the learning effectiveness and cost-effectiveness, as well as the potential of a hybrid education model that combines both human and AI technologies.

In the third step, this paper examines the high-performing education systems of Finland and Singapore. While these countries pursue different educational approaches, they converge on key factors such as linking education to the 4IR, focusing on problem-driven and project-based learning, and investing in teacher capacity building.

In the fourth step, this study evaluates current initiatives on how AI has been implemented to address the challenges that Afghan girls and women encounter. In this final step, the study identifies current gaps and proposes the use of open-source technologies such as Edge AI and Local Large Language Models (LLMs), illustrating that they possess the adaptability to function offline and offer a cost-effective option for developing a full-scale mentorship AI model specifically tailored to the Afghan context.

These models may address key challenges, such as policy restrictions, limited access to technology, and poor internet connectivity in Afghanistan. Open Source and Edge AI may enable adaptive, personalized education available 24/7. This study proposes an offline mobile and computer application, similar to the Kolibri open-source model, but equipped with AI, with only periodic updates and support for English, Pashto, and Dari.

AI and digital technology have significant transformative potential and can address these challenges, helping Afghan girls and women reach their full potential. The key is to link future skills to measurable economic returns and 4IR and 5IR. These technologies can help Afghan women and girls achieve self-sufficiency and independence. Within this context, the following sections examine the concepts of 4IR and 5IR. The skills Afghan women and girls need to succeed in a rapidly evolving technological era. The study also explores the types of education systems that are most effective in developing these competencies.

1.2 Fourth and Fifth Industrial Revolutions

Klaus Schwab coined the 4IR term. In his book "The Fourth Industrial Revolution", Schwab (2016) suggests that this Industrial Revolution will transform the way we live, work, and socialize. Unlike previous industrial revolutions, which progressed linearly, the 4IR is advancing at an exponential pace. It builds on digital technology and integrates various innovations, leading to paradigm shifts in the economy, business, society, and individual life. Ultimately, it will transform entire systems within countries, companies, industries, societies, and educational institutions. The basis for this revolution is big data, high computing power, and digital technologies that connect the physical world to the virtual one.

According to the World Economic Forum (2023), employers not only require skills, such as creativity, critical thinking, problem-solving, and IT, but also place strong emphasis on interpersonal and socio-emotional skills. These skills enable individuals to collaborate, coordinate, and communicate effectively. Furthermore, Li (2022) identified problem-solving, critical thinking, analytical thinking, and innovation as key skills for thriving in the 4IR, alongside technical and field-specific

Consequently, a paradigm shift in our education system is necessary to establish a new relationship among education, the market, and society, empowering students to thrive in a rapidly changing world. The important question is: what kind of education system would facilitate such a transition and paradigm shift? The World Economic Forum defines such an education system as "Education 4.0." This system is designed to empower young learners and develop future-oriented capabilities, skills, and mindsets that are unlikely to be replaced by technology (World Economic Forum, 2023). Education 4.0 is discussed in the following section. This section will examine the 4IR and 5IR.

According to Mahiri et al. (2023), 4IR has fundamentally transformed manufacturing by integrating various technologies to automate and optimize production and productivity. On the other hand, 5IR focuses more on human–machine collaboration and interaction by implementing the 4IR principles, such as advanced digitalization, big data, the Internet of Things, AI, and automation, to achieve productivity and accessibility. 5IR is built on three core principles: human-centricity, resilience, and sustainability.

Saniuk et al. (2022) suggest that 5IR brings back the human factor in industry, fostering collaboration between people and "intelligent production systems." 5IR differentiates itself from 4IR by including the dynamics of human–machine interactions, such as augmented reality technology. This process will expedite digitization through human roles and participation. The authors argue that the entire education system, particularly vocational education and universities,

should redesign their programs to prepare students for the cyber-physical world, both as users and as designers.

Consequently, Fogaca et al. (2025) argue that "this integration prioritizes the collaboration between humans and advanced technologies to create adaptive, inclusive, and eco-friendly systems that benefit society as a whole" (para. 1). Figure 1.1summarizes the similarities and differences between the two revolutions:

Figure 1.1: Similarities & Differences Between 4IR and 5IR

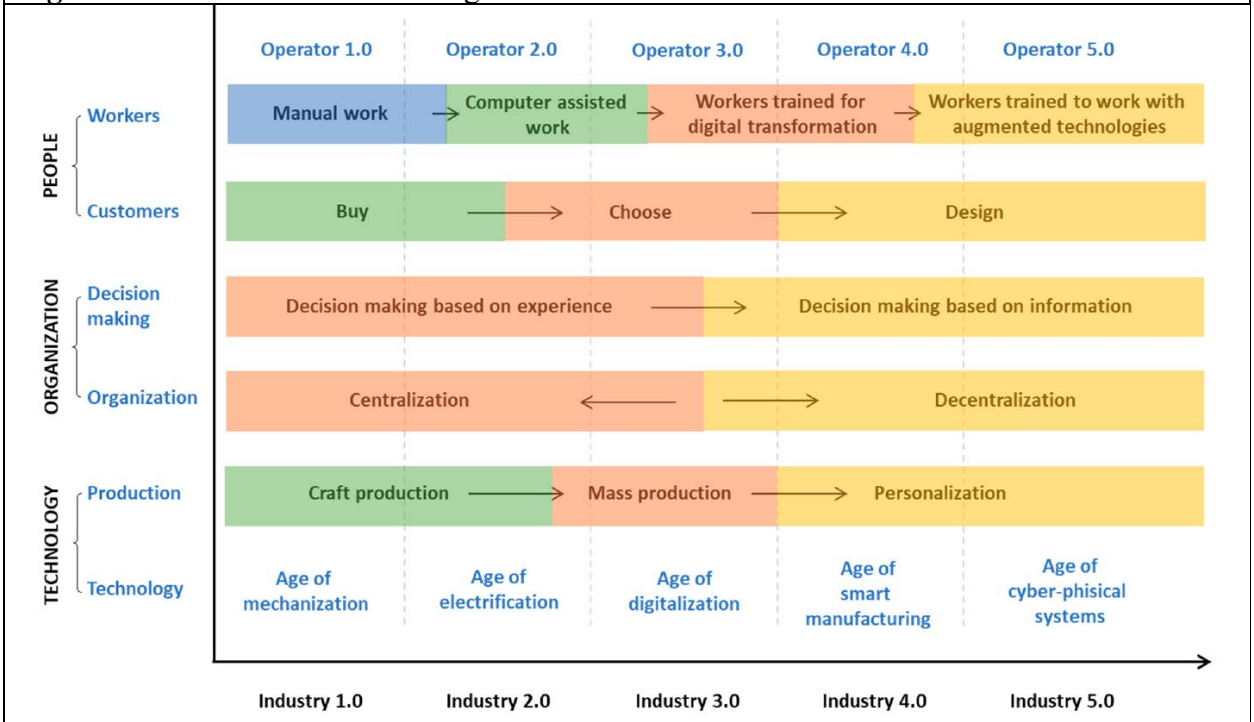
Similarities	Differences
Shared Technological Foundations: rely on IoT, Big Data, AI, and CPS	Primary Focus: 4IR emphasizes automation and mass production, whereas 5IR incorporates human-centricity, sustainability, and resilience
Efficiency and Productivity: aim to enhance industrial performance and operational efficiency	Environmental Perspective: 4IR's sustainability efforts are secondary, mainly targeting process optimization, while 5IR integrates sustainability as a core principle
Customization: promote personalization of products and services	Workforce role: 4IR minimizes human intervention through automation, while 5IR places humans at the center of production, emphasizing collaboration between workers and machines
Influence on Industrial Models: reshape business strategies and production systems	Impact: 4IR is more restricted to industrial transformation, while 5IR extends beyond factories to address societal challenges

Source: (Fogaça, Grijalvo, & Neto, 2025)

Furthermore, Zizic et al. (2022) suggest that this paradigm shift places humans at the center of production, leads to more personalized products, and transforms future work into more meaningful and purposeful employment.

Furthermore, they suggest that knowledge in data science and machine learning is key for future jobs. Figure 1.2 summarizes the transformation paradigm in all Industrial Revolutions.

Figure 1.2: Transformation Paradigm in Each Industrial Revolution



Source: (Zizic et al., 2022)

According to the World Economic Forum's "The Future of Jobs Report 2025", between 2025 and 2030, the 4IR is expected to create 170 million jobs and displace 92 million jobs, representing a 7% growth in total employment globally. Both the risk and opportunity are great. "Technology-related opportunities are the fastest-growing sector, including Big Data Specialists, Fintech Engineers, AI and Machine Learning Specialists, Software and Application Developers, and green and energy transition roles, including Autonomous and Electric Vehicle Specialists, Environmental Engineers, and Renewable Energy Engineers" (World Economic Forum, 2024, p. 6).

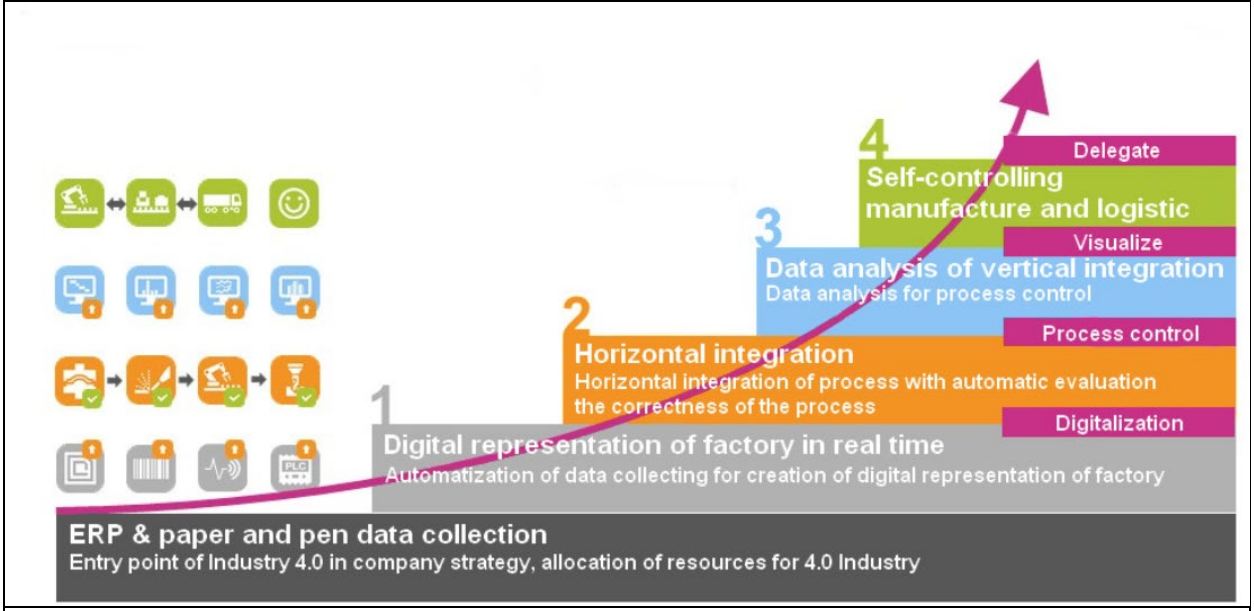
AI, big data, and cybersecurity will have huge potential in the future. Creativity, innovation, resilience, and collaboration will be crucial for success in the era of 4IR. These skills will enable individuals to adapt, learn, and unlearn in a highly complex and rapidly changing context. Finally, roughly 39%, or two-fifths, of skill sets may be outdated or transferred (World Economic Forum, 2024). The key question relates to what kind of education system will prepare the students and society, particularly girls and women in Afghanistan. The simple answer is the Education 4.0 framework. "[It] is a response to the needs of IR4.0 where human and technology are aligned to enable new possibilities" (Hussin, 2018, para. 1). The next section explores this question.

Scholars and theorists have critically examined the development of Education 4.0 to study the integration of technology and education, and how they interact to shape the future of education in response to the need for innovation and a rapidly changing world (Hussin, 2018). On this basis, the Education 4.0 framework aims to prepare students for the 4IR. Thite et al. (2021) suggest that an education ecosystem for learning should be designed to promote self-regulated learning, critical thinking, collaboration, and teamwork skills, supported by digital technology.

In addition, Büyükozkan and Mukul (2023) recommend that shifting from a traditional, memorization-oriented education system to Education 4.0 requires a paradigm shift that integrates technology into the education system to respond to the emerging needs of 4IR. Consequently, Education 4.0 encourages students to keep up with the era of innovative and rapid change. It helps students develop a mindset of self-learning to adapt and learn based on the needs of contemporary change in society, with a strong focus on the application of technology, leading to lifelong learning and self-improvement.

Benešová and Tupaa (2017) suggest that 4IR has four implementation phases, each requiring specific skill sets. Figure 1.3 simplifies the implementation phases.

Figure 1.3: 4IR Implementation Phases



Source: (Benešová & Tupa, 2017)

First phase – "Digital representation of factory in real time": In the first phase, companies require an effective information system, such as Enterprise Resource Planning. The first phase is about mapping the company's processes, products, policies, clients, and services. To complete this process, companies need process engineers who are knowledgeable and experienced in the field of mapping processes. Furthermore, in this phase, companies are also required to create digital data to increase the volume of data storage for automation and decision-making by machines. The high demand for data storage will drive increased demand for cloud systems and services. Companies like Microsoft, Amazon, Google, and other data companies will need cloud system engineers and integrators (Büyükozkan & Mukul, 2023).

Second phase – "Horizontal integration": The second phase focuses on automation and reengineering of the production process. To implement this part, process engineers are required again. The automated machines have the capabilities of telematics and diagnostic systems, which can collect and analyze data (Büyükozkan & Mukul, 2023).

Third phase – "Data analysis of vertical integration": The third phase is about complex methods of data processing and analysis. A significant challenge of the 4IR is the unanticipated and rapid surge in demand for data analysts. 4IR requires data analysts who are knowledgeable in a specific field, including skills in data analysis and the production process. The high and rapid demand for specialized skills will be significant for 4IR (Büyükozkan & Mukul, 2023).

Fourth phase – "Self-controlling manufacture and logistics" – This phase will help lead to autonomous manufacturing. Companies also need operators, maintenance workers, data analysts, process engineers, and quality controllers. Automation and self-optimizing systems will further maximize productivity (Büyükozkan & Mukul, 2023). Figure 1.4 summarizes the Qualifications and Skills for 4IR in the IT field. The next section examines Education 4.0. The next section focuses on the education and building of these capabilities.

Figure 1.4: Qualifications and Skills

IT Job Profile	Qualification	Skills
Informatics Specialist	Secondary / postgraduate education in IT Practice on a similar position Advanced knowledge of large domain and network management Basic knowledge of working with databases, virtualization and cloud services	Language skills - English, German etc. Autonomy; Responsibility; Flexibility Communicativeness Reliability Ability to plan, lead a small team, organizational skills Problem solving
PLC Programmer	Secondary school education focused on electrical engineering Practice Proven experience in programming of machinery Programming and knowledge of PLC	Language skills - English, German etc. Knowledge of working with Beckhoff TwinCAT Responsibility; Flexibility; Communicativeness Reliability; Ability and willingness to learn new things
Robot Programmer	Knowledge of off-line and on-line robot programming Experience with basic robot parameterization and calibration Project management, co-ordination of the robot	Language skills - English, German etc. Analytical/Logic thinking Responsibility Flexibility Communicativeness Reliability

	programmer team and coordination with PLC programmers Secondary / post graduate education focused on automation technology Installation of the device into operation	Knowledge of the simulate process; Problem solving
Software Engineer	Secondary / postgraduate education in IT Knowledge of C/C++ programming Knowledge of C# / .NET Practice Basic knowledge of working with databases (SQL)	Language skills - English, German etc. Autonomy; Creativity; Flexibility Analytical/Logic thinking Problem solving
Data Analyst	Secondary / postgraduate education in technical or mathematical / statistical direction PL / SQL – advanced UML - advanced	Language skills - English, German etc. Autonomy; Creativity; Flexibility; Analytical/Logic thinking Knowledge of working with a spreadsheet (Excel) Basic knowledge statistically Problem solving
Cyber Security	Secondary / postgraduate education in IT	Language skills – English Autonomy; Responsibility; Creativity; Cooperation Ability and willingness to learn new things Analytical/Logic thinking Knowledge of security standards and communication standards Knowledge of servers (level - administrator)
Source: (Büyükozkan & Mukul, 2023)		

1.3 Education 4.0

Mukul and Büyükozkan (2023) define Education 4.0 as the future design and vision of learning. The overarching objective of Education 4.0 is to leverage digital technologies and personalized data to equip students for the 21st century. AI, virtual reality, and the Internet of Things are among the critical innovations of 4IR, combined with digital technologies. Therefore, Education 4.0 is

designed to equip students with the knowledge and abilities to thrive in a rapidly and continuously changing digital world (Sharma et al., 2025).

Youngkin (2014) suggests that Education 4.0 is a new paradigm that transforms learning, students, teachers, and schools based on the needs of 4IR and 5IR. One of the innovative ways of teaching is the flipped classroom model, which allows students to explore and examine lessons available through digital sources, such as videos, presentations, and lectures, outside of the school and classroom. Consequently, students utilize classrooms for discussion, problem-solving, and teamwork. In such a model, the responsibility lies with the student to achieve their objectives and goals. Education in this paradigm is project-based and individualized, and resources are accessible from anywhere at any time (Himmetoğlu, Aydoğ, & Bayrak, 2020).

According to Miranda et al. (2021), four key enablers need to be taken into account for designing the Education 4.0 teaching and learning process and system: (1) determining and identifying soft and technical skills necessary for the student to acquire; (2) adopting innovative pedagogical approaches and different modalities for information transfer and teaching–learning methods; (3) implementing and adopting technology-based training, tools, and platforms; and (4) employing innovative infrastructure to improve learning in the classroom, outside the classroom, and at the institutional level (Miranda, Ramírez-Montoya, & Molina, 2021).

Sharma et al. (2025) identify five clusters of research related to Education 4.0. The first cluster comprises the blueprint for Education 4.0 based on 4IR. It focuses on innovative pedagogical methods that emphasize digital literacy, project-based learning, personalized learning, and computer-based learning. These approaches help students acquire skills such as critical thinking, teamwork, creativity, and effective communication, in addition to specific field knowledge and experience. All these skills are necessary to thrive in the 4IR. According to Fisk (2017), institutions should develop a roadmap or blueprint to integrate and implement this innovation in the educational system (Sharma et al., 2025).

The second cluster must focus on preparing students for the future changes and challenges of learning. According to Shahroom and Hussin (2018), education should develop students' capabilities and abilities that are unlikely to be replaced by AI and robots. Consequently, due to rapid economic, social, and technological changes, schools/universities must design plans to prepare students for jobs that have not yet been created, technologies that have not been developed/invented, and problems that our society doesn't know about (Shahroom & Hussin, 2018).

The third cluster is defined as education for sustainable development, which encourages educators to raise students' awareness of sustainable development by offering courses such as environmental chemistry to address sustainability issues (Sharma et al., 2025).

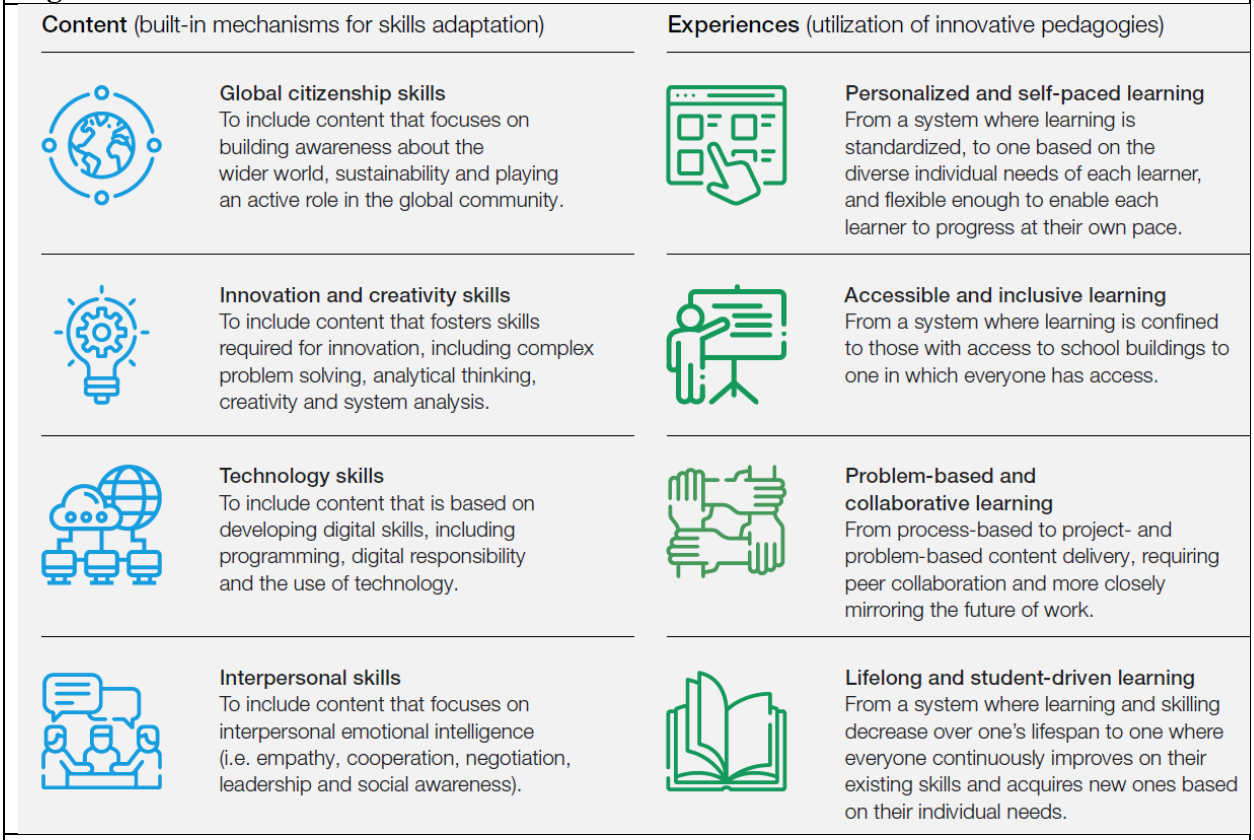
The fourth cluster focuses on enhancing both hard and soft skills and employing a digital library to improve people's interaction, cooperation, and ability to lead teams through an online modality.

Finally, the fifth cluster is about innovation and creativity. The underlying assumption of Education 4.0 is that it uses digital technology, data, and AI to support students and foster a culture

of creativity and innovation. As a result, cultivating a culture of innovation and creativity is a key part of education (Sharma et al., 2025).

The World Economic Forum's Education 4.0 framework suggests that education for the future must focus on skills and capabilities unlikely to be replaced by technology. It provides the following framework for Education 4.0, including eight guiding principles that help students achieve their full potential to thrive in the 4IR, as seen in Figure 1.5 (World Economic Forum, 2023).

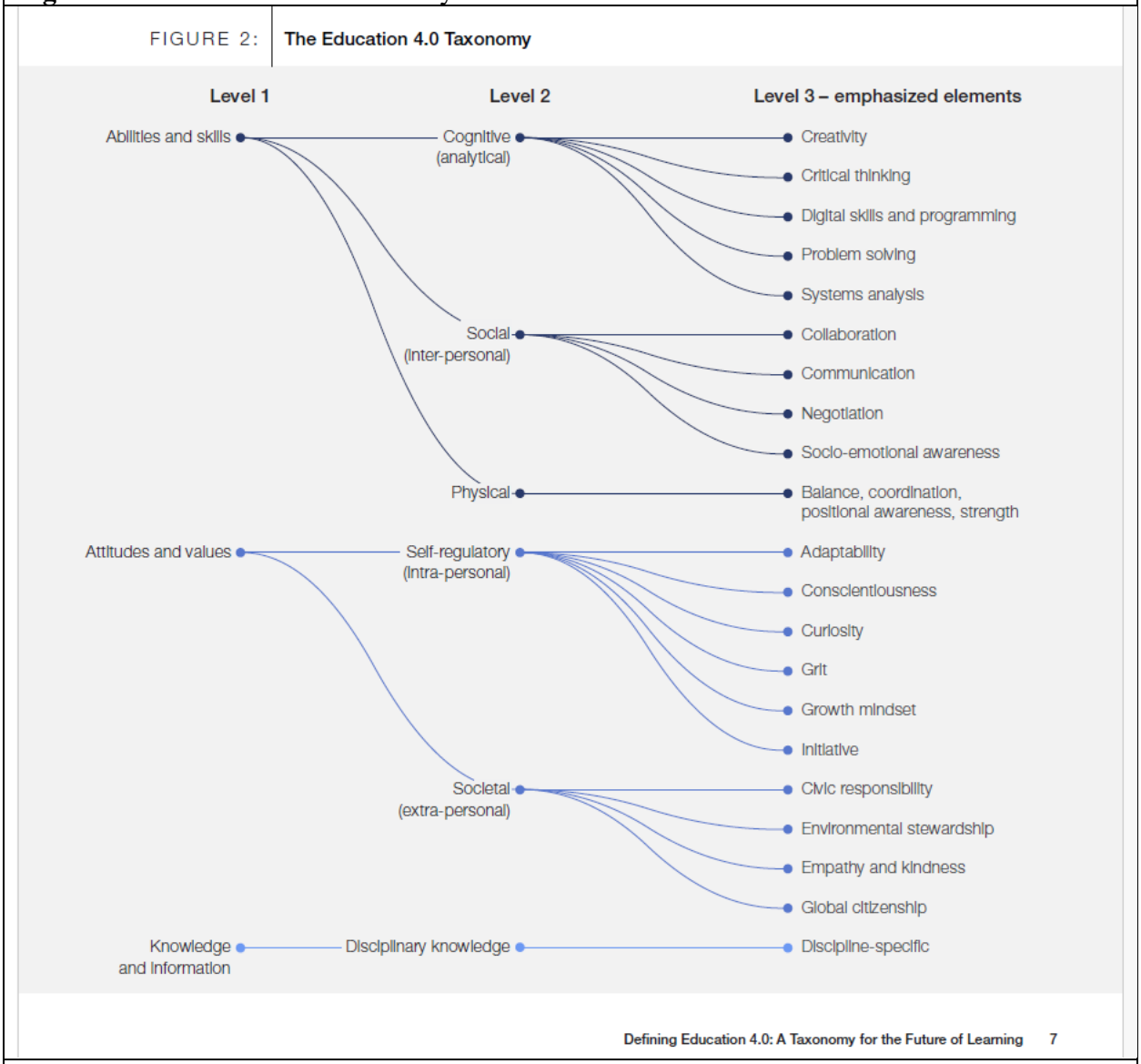
Figure 1.5: The World Economic Forum's Education 4.0 framework



Source: (World Economic Forum, 2023)

Furthermore, the World Economic Forum (2023) also provides "a comprehensive set of aptitudes, organized into a tree structure. Aptitudes are the abstract, transferable aspects of learning. They are teachable and learnable qualities – not innate characteristics". The report also identified three types of aptitudes: "(1) abilities and skills, (2) attitudes and values, and (3) knowledge and information" (p.7). As seen in Figure 1.6. Education 4.0 places strong emphasis on the first two, as current experts and employers emphasize the importance of these learning areas for future jobs and opportunities.

Figure 1.6: Education 4.0 Taxonomy



Source: (World Economic Forum, 2023)

1.3 a: Abilities and skills

According to the World Economic Forum, abilities and skills are process-oriented capabilities to achieve a goal. They are divided into groups: (1) cognitive and analytical aptitudes, including creative critical thinking and problem-solving, interpersonal, communication, collaboration, and

emotional intelligence. A recent study reviewed 2 million online job postings. The study identified five top skills that companies require, including communication, creativity, collaboration, creative problem-solving, and critical thinking. The same study found that the requirements for digital literacy grew by 158%, for critical thinking by 158%, and for creativity by 65% (World Economic Forum, 2023).

1.3 b: Attitudes and values

Attitudes and values include the set of beliefs that determine people's behavior, such as motivation and engagement with society, including moral and ethical considerations. Given the context of the 4IR and 5IR, which include rapid technological advancements, they should be based on a set of values that are fair, protect the safety and freedom of individuals and communities, and are designed according to educational guidance to preserve the values and needs of a just society (World Economic Forum, 2023).

1.3 c: Knowledge and Information

Knowledge and information have always been at the core of education and learning. With the emergence of new technologies, the way raw information is utilized and how people interact has changed significantly. For example, the proliferation of the internet, mobile devices, and AI has made it easier to generate and share knowledge with the public. However, this has also created challenges in collecting, processing, interpreting, and utilizing that knowledge. For this reason, new skills and capabilities are required to guide students in systematically and appropriately interpreting and utilizing knowledge and information. Consequently, Education 4.0 focuses more on developing those essential skills and capabilities needed to interpret and utilize information and knowledge that is grounded in appropriate attitudes and values for a better shared humanity (World Economic Forum, 2023).

In summary, Education 4.0 has evolved to address the needs of the 4IR and prepare students for future opportunities. Education 4.0 focuses on employing and integrating technologies such as AI and data analysis to develop personalized, preference-based, problem-solving, and innovative learning approaches in response to rapid technological change and evolving individual capabilities and preferences. According to the World Economic Forum (2023), Education 4.0 requires collaboration among multiple stakeholders, including business, government, civil society, and think tanks. The next section explores how AI can help achieve Education 4.0.

Section 2: AI & Education 4.0

2.1 AI & Education 4.0

As Schwab (2016) suggested, unlike other revolutions, the 4IR has an exponential pace, and the development and change will be rapid and drastic. There is an urgent need to support education in managing the opportunities and risks that the revolution presents. According to the World Economic Forum, AI presents a unique opportunity to enable Education 4.0, which focuses on students by equipping them with the abilities, skills, attitudes, and values necessary for the future.

AI can revolutionize teaching, personalize learning, and automate administrative processes. AI integration should be strategically planned to complement teachers' roles rather than replace them. Automation of administrative tasks and the provision of individualized student data will enable teachers to allocate more time to working directly with students and to tailor education programs to their needs, helping them achieve their full potential. More specifically, according to the World Economic Forum (2024), AI has immense potential to help achieve Education 4.0 in the following ways: (1) personalized and adaptive learning, (2) assessment and feedback, and (3) automation of administrative tasks.

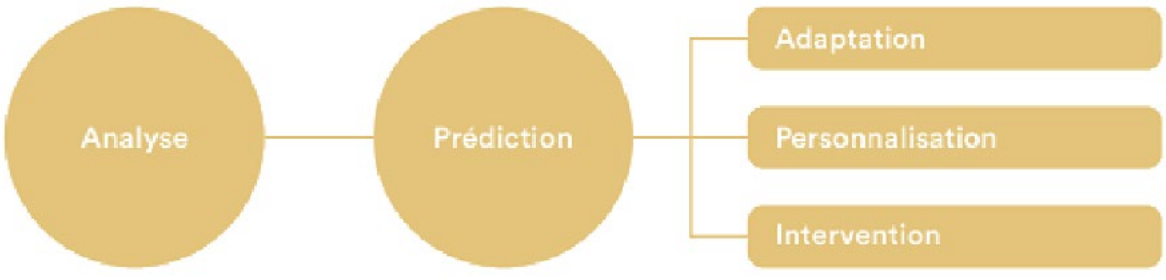
2.2 Adaptive and Personalized Education

An OECD report defines the adaptive learning approach as one that can "detect the knowledge (or knowledge gaps) of students; they diagnose the next appropriate steps for students' learning; they act by providing new exercises, new curriculum units, some form of instruction, or just notifying the teacher" (OECD, 2021, p. 15).

Motahhir and Bossoufi (2023) define adaptive learning as a learning model that provides personalized feedback, real-time assessment and personalized learning plan. This adaptive learning has been made possible by machine learning algorithms that infer from students' responses and interactions in real time. For example, when the machine diagnoses students' errors or clears their doubts.

The authors characterize this potential of AI as intelligent, as it adapts to the needs of individual learners. Consequently, "adaptability is understood to mean the ability of the learning environment to modify its behavior based on inferences made according to the updated content of a model of the learner, whether on his cognitive, metacognitive or affective state" (Motahhir & Bossoufi, 2023, p. 143). Furthermore, this adaptive and personalized learning monitoring has been facilitated by collecting and using data. The following model in Figure 2.1 summarizes data collection and analysis processes.

Figure 2.1: Adaptive and Personalized Learning Through Data



Source: (Motahhir & Bossoufi, 2023)

Motahhir and Bossoufi (2023) suggest that in a traditional class, it is difficult for the teacher to take into account the needs of diverse students. However, AI can simplify this process of personalizing a program through adaptive learning. Walkington and Sherman (2012) studied 145

context-personalized learning activities through an experimental approach to understand what makes adaptive and personalized education more effective. Their findings suggest that interest-based interventions could help students make the connection between personally relevant contexts and the abstract world. Consequently, they suggest a new direction for adaptive and personalized education that is interest-driven and deeper and more meaningful by leveraging personalization through interest, potentially leading to highly motivated students.

Walkington et al. (2012) argue that technology offers personalized learning by employing data analytics and adaptive educational technology, and individualized learning, such as feedback from real-time data, performance measurement, and adapting to the ability of the students. However, the main challenge remains how to improve the adaptive and personalized learning environment to promote self-regulated learning. The adaptive and personalized approaches and technologies focus more on students' performance (cognition), while paying less attention to motivation and emotion. Consequently, they suggest employing multimodal data to detect and analyze the cognitive, metacognitive, affective, and motivational states of students. This approach will allow the design of a learning plan to provide holistic support, potentially leading to closer cooperation between education and psychology (Walkington & Sherman, 2012).

2.3 Assessment and Analytics in Education – AI Tools

According to the World Economic Forum, unlike traditional assessment, a time-consuming and linear approach, AI automation enables teachers and educational institutions to provide real-time feedback on a large scale. Not only can AI assessment provide immediate feedback to help students understand their mistakes, but it can also support teachers with assessments in designing a tailored program for each student, leading to the personalization of education and courses. Such assessments can be well-designed in collaboration with teachers to train the AI to evaluate non-test assignments such as projects, essays, and other innovative work. Both AI analytics and machine learning can enable the education system to be more agile, timely, and responsive, providing teachers, students, and parents with real-time feedback. This would enable them to make informed and adaptive decisions to help students achieve their potential (World Economic Forum, 2024).

Luo et al. (2025) note that one of the core functions of AI in education is assessment and evaluation. These AI tools can assess students' understanding and knowledge, automate grading, and provide large-scale and personalized feedback. Furthermore, Natural language processing (NLP), a subfield of AI, has been very useful in processing large-scale text or writing assignments. Gao et al. (2023) identified five categories of text-based automated assessment systems: "(1) Automatic Grading System; (2) Automatic Classifier; (3) Automated Feedback System; (4) Automated Writing Evaluation System; and (5) Multimodal Evaluation System" (p. 7).

Furthermore, according to Kabudi et al. (2021), based on the 46 papers reviewed, various AI and data analytics techniques were employed, such as descriptive, predictive, and prescriptive analytics. The most widely used method was predictive analytics based on statistical analysis to determine future outcomes. They suggest that "predictive analytics methods and related techniques, specifically naïve Bayes, fuzzy logic, Bayesian networks, neural networks, and

Bayesian knowledge tracing and association rules mining, have been shown to enhance students' learning performance, personalized learning, motivation, and achievements" (p. 9).

Luckin (2017) highlights that the evidence examined with the current AI system is positive. For example, AIAssess was developed at the UCL Knowledge Lab to assist students with math and sciences. It examines student learning in real time and utilizes an adaptive approach to increase in difficulty as the student learns. The software evaluates individual students' knowledge of the subject and metacognitive awareness, potentially enabling predictive analytics for students' future performance.

The software utilizes a three layers system: (1) a knowledge component that gathers data on science and mathematics to evaluate students' work on the subject matter; (2) an analytic component that collects information about the students and how they interact with the software; and (3) a student model component that focuses on metacognitive awareness. Consequently, this software is designed to provide step-by-step and detailed feedback about the correct and incorrect steps for solutions. While AI Assess is well-designed, it needs further evaluation to determine how effective it is (Luckin, 2017). The next section will analyze AI-enabled education model cases for replicability, systematic and step-by-step knowledge, and policy options.

Section 3: Research Design and Methodology

This study employs an in-depth case study approach and a process-tracing method to generate practical, step-by-step knowledge for practitioners and experts to design context-specific, tailored hybrid education models in other contexts. The case study is structured around a problem-solution and result framework. This approach enables this study to analyze systematically how leaders and practitioners addressed the education problem by employing AI and pedagogical approaches that support Education 4.0. Insights from this study provide both practical guidance for other contexts and a foundation for designing tailored, context-specific solutions. Furthermore, the outcome evaluation measures the effectiveness of the solutions developed to address identified systemic challenges. The next section explains the selection criteria.

The World Economic Forum's Education 4.0 includes four criteria for selecting cases of AI education models. The criteria include significance, quantifiability, scalability, and sustainability (World Economic Forum, 2024). To produce useful and step-by-step knowledge, the case studies are further organized as follows: (1) problem, (2) solution, and (3) results.

Section 4: Case Studies

4.1 Case Study 1: Letrus – Brazil

4.1a Problem

According to UNESCO (2023), functional literacy in Brazil remains low. The Programme for International Student Assessment (PISA) report also indicates that scores for Brazil and Latin

American countries are below the OECD average. In addition, a significant literacy gap exists between low and high-income students (World Economic Forum, 2024). Finally, only 2% of students in Brazil achieve the highest literacy score (JET Education Services, 2021).

4.1b Solution:

The Letrus Program is an AI-powered literacy development initiative. It has been implemented across 670 schools, benefiting 170,000 students. The overarching objective of the program is to improve the functional literacy rate. The Letrus Program is built on Natural Language Processing AI technology that provides real-time feedback and evaluation for reading and writing. Furthermore, the program is designed using an adaptive learning method and combines AI and human support for feedback and evaluation, offering a more personalized learning experience. This personalized learning, powered by AI, can provide students with immediate feedback, real-time data for teachers, and a monitoring tool for school managers. Teachers receive recommendations to tailor content and methodologies for specific skill development. Finally, AI can also provide managers with tools to monitor progress and receive detailed feedback. This would allow managers to plan and design teacher-training programs or adjustments to the education strategy to help implement Education 4.0 (World Economic Forum, 2024).

4.1c Evaluation - Impact:

The Letrus program has reached 957 schools, 1,327 teachers, and 116,677 students. UNESCO also reported a 10 % improvement in students' writing proficiency following the submission of five essays. The Letrus program demonstrated the potential to narrow the knowledge gap between public and private schools by 20% (UNESCO, 2023). In 2022, after implementing the program in a public school in Espírito Santo, students from that school achieved second place in the national writing exam within 5 months, illustrating the program's notable success when combined with human support. The control group finished in eighth place. "Espírito Santo emerged as the top-performing state in the writing component of the National Exam, exhibiting a performance delta five times the national average from 2021 to 2022" (World Economic Forum, 2024, p. 17).

4.2 Case Study 2: Kabakoo – Africa

4.2a Problem:

Each year in Africa, more than 10 million young people struggle to enter the job market, yet the formal sector creates only 3 million jobs. This situation particularly impacts marginalized, non-urban, and less-educated young Africans, as these jobs are mostly reserved for the urban elite. Coupled with norms-based discrimination, these conditions disproportionately affect women (Azurit Foundation). Finally, according to the World Economic Forum, 80% of employment in Africa is informal, and access to formal employment is limited (World Economic Forum, 2024).

4.2b Solution:

In this context, Kabakoo aims to address these challenges by educating young Africans with "entrepreneurial mindsets and practical competencies", helping them achieve their potential for self-employment. Kabakoo's pedagogical approach is community-driven skill-building combined with a mobile application, complemented by peers and mentors. Kabakoo designed a mobile AI app that enables experiential learning through digital modules and 24/7 support virtual support. The virtual mentor offers guidance and advice, which is complemented by the mentors and experts. The AI-powered app can also provide personalized feedback to each student via WhatsApp upon assignment submission. The app is equipped to verify students via selfie (World Economic Forum, 2024).

Furthermore, Kabakoo has three strategic approaches to delivering Education 4.0 quality and preparing students for a digitalized, rapidly changing environment. First, it combines high-tech with indigenous knowledge, focusing on how young people solve real-world problems through project-based learning. Second, AI education is complemented by local and global professional mentors. Third, learning is self-paced and data-driven, with learners conducting self-evaluations using the digital app. Finally, in addition to building 4IR skill sets, the program focuses on developing minds and fostering lifelong learning (Azurit Foundation).

4.3c Evaluation - Impact:

Kabakoo learners reported a 44% increase in their income. (World Economic Forum, 2024). Boubou, a Kabakoo learner, said, "Since I dropped out of high school, my family was pushing me to go to Europe through the Sahara route. But with Kabakoo, I became confident in my abilities to shape my life and my community. Now I am serving my clients with automated irrigation solutions I developed as part of my learning project at Kabakoo" (Azurit Foundation).

4.3 Case Study 3: 3D Africa for Girls - Youth for Technology Foundation

4.3a Problem

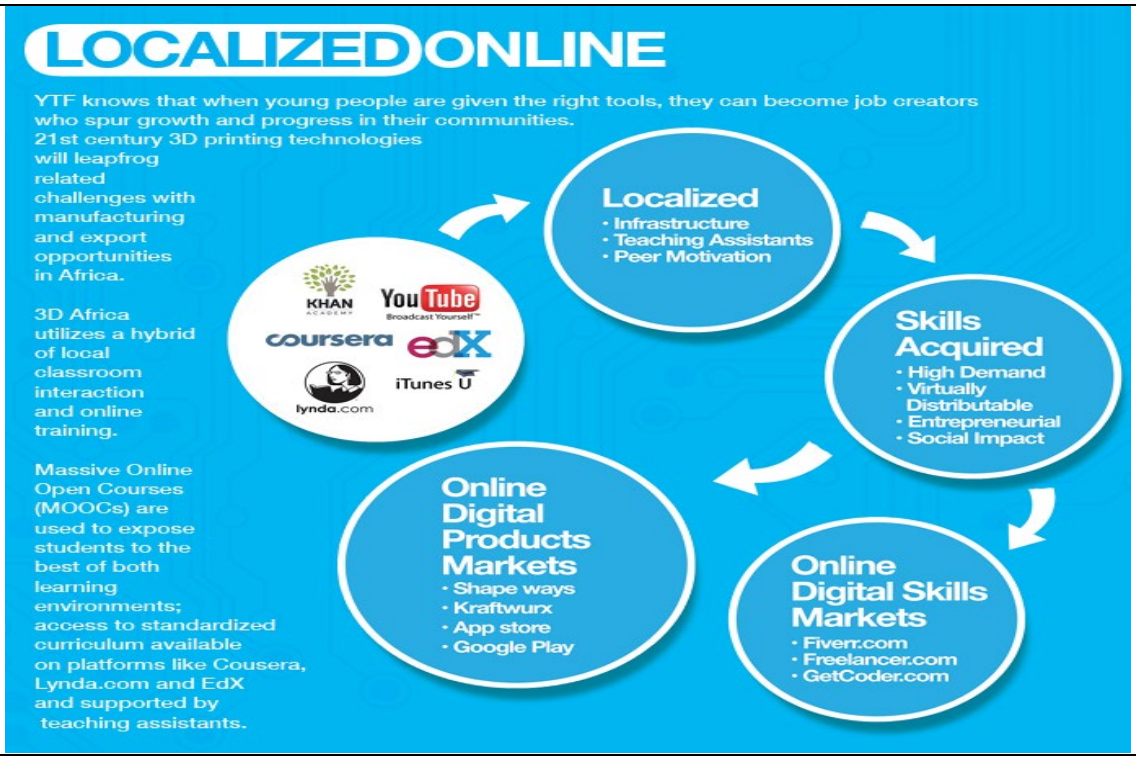
African countries are aid-dependent, and most modern technology and equipment are imported. This program encourages girls aged 10 to 16 to design and develop innovative STEM-based solutions to address real-world problems (World Economic Forum, 2023). Furthermore, the program aims to increase participation in STEM-related fields.

4.3b Solution:

"3D Africa combines programming and entrepreneurship; empowering girls as problem solvers and inventors, helping to solve the STEM gender gap in Africa" (Layton, 2015). The platform educates girls aged 10-18 in the STEM field to empower them to design, prototype, market, and sell their 3D-printed productions and solutions. The goal is to empower girls with the capabilities to employ STEM-based solutions to real-world problems and design suitable solutions. Furthermore, the program provides marginalized, low-income girls and women with the skills to design context-specific solutions and market their products through local and global online platforms. The educational model is further supported by job-shadowing, mentoring, 3D design, and prototyping. For example, girls use "computer-aided design to turn their ideas into new

products (such as 3D printed rechargeable, detachable, cordless hair dryers and African-designed furniture) and market their goods". Finally, the program also includes programming, which is the backbone of the AI (World Economic Forum, 2024, p. 20). Figure 4.1 summarizes the education model that targets future opportunities.

Figure 4.1: Education Model



Source: (Youth for Technology Foundation, 2016)

4.3c Evaluation - Impact:

90% of graduates from Youth for Technology Foundation enrolled in a university or tertiary institution. Over 85% chose STEM or technology as their careers. The program for the student was highly successful. Over 90 percent of students achieve proficiency levels above 95% in basic and advanced technology (World Economic Forum, 2024). One student remarked: "I can now model and print consumables and electronic components. I have been printing jewelry like rings and bracelets and selling them to my classmates. The world needs more female innovators to tackle the toughest challenges we have today."– Treasure, 15-year-old participant (Youth for Technology Foundation, 2015). According to Grand View Research (2022), the global 3D printing market size could reach USD 88.2 billion by 2030. Consequently, this sector has huge potential and can provide good job opportunities for women.

4.4 Case Study 4: AI Tutor Project - Ministry of Education of the United Arab Emirates

4.4a Problem

The AI Tutor Project aims to address three important issues: (1) some students may not learn a topic or may have difficulty fully understanding it in the classroom; (2) closing the equity gap between those who can afford private tutoring and those who cannot (World Economic Forum, 2024); and (3) the goal of leveraging AI and other digital tools to reach the performance levels of global top-tier education systems, as stated by the UAE Minister of Education, Dr. Al Falasi (World Economic Forum, 2024).

4.4b Solution

The AI-powered tutor was designed jointly by the Ministry of Education of the United Arab Emirates, Microsoft, ASI, teachers, and other local partners. The project was designed and equipped with adaptive learning algorithms, regular feedback and assessment, 24/7 availability, and data-driven analytics. The overarching objective of this AI-powered tutor is to improve student performance by increasing test scores, subject comprehension, and critical thinking skills. The Ministry of Education of the United Arab Emirates and its partners have been working to develop and design engaging, interactive learning materials. Furthermore, the project's overarching objective was to improve critical thinking, problem-solving, self-directed learning, and digital literacy. Additionally, this project also helped teachers to focus on interpersonal and socio-emotional development (World Economic Forum, 2024).

4.4c Evaluation and Impact

UEA launched this AI tutoring education model in September 2024. The preliminary data show a 10% improvement in students' learning outcomes. Furthermore, the data also indicates a positive correlation between the AI education model and students' academic performance. However, further research is needed to evaluate the recent results and outcomes (World Economic Forum, 2024).

In addition to these case studies, Yi et al. (2024) reviewed 40 samples obtained from 21 articles published between 2000 and December 2023. This study suggests that "on average, the overall effect size was 0.343 under the random-effects model, showing a small and positive effect. This indicates that students who learned mathematics using AI technology performed better compared to those who learned without it" (p.1119).

Furthermore, the same study evaluated the effectiveness of these AI models: an intelligent tutoring system (ITS), an adaptive learning system (ALS), and a pedagogical agent (PA). Their findings suggest that "the use of ITS and ALS had significant positive effects on mathematics learning, ITS (g = 0.432**) and ALS (g = 0.347**). However, the use of PA did not show significant results"

(Yi et al., 2024, p. 1119). Please see the footnote links for examples of AI and digital education models.[1] The next section focuses on contextualizing the AI education model for Afghanistan.

Section 5: Contextualizing AI-Powered Education Model for Afghanistan

This section constitutes the core of this study. First, it examines how Afghanistan's underperforming education curricula and system can be reformed to provide Afghan girls and women with high-quality education, enabling them to achieve their full potential in the era of the 4IR and 5IR. To provide evidence-based policy recommendations for this paradigm shift, this study examines two high-performing education systems: Singapore and Finland. These two countries differ in their context and educational approaches; however, they also converge on key education policies and strategies. Selecting a very different case study may enable this study to generate replicable knowledge for other contexts. This study also draws on PISA recommendations, which are based on data from nearly 700,000 students across 81 countries and economies (OECD, 2023).

Secondly, this study examines the integration and implementation of AI in the Afghan education system. This approach will enable this study to examine the key challenges, gaps, and opportunities in implementing an AI model for Afghan girls and women. This analysis includes SOLAx, which utilizes generative AI to digitize the Afghan school curricula and has deployed a generative AI-driven learning model via WhatsApp. The in-depth analysis of this case study and its findings will enable this research to critically examine the gaps, feasibility, and opportunities in implementing an AI education model for Afghan girls and women.

Finally, the study synthesizes insights from four global AI education case studies from this paper and one specific case from Afghanistan. It also combines these solutions with lessons from the Finnish and Singaporean education systems and PISA findings. These elements inform a tailored, context-specific design of an AI education model for Afghanistan, linking education to the 4IR, 5IR, and future job opportunities. This research concludes that to prepare Afghan girls and women for the 4IR and 5IR, it is essential to reform Afghan school curricula and pedagogical approaches, linking education to these technologies and future opportunities. The proposed AI education model for Afghan girls and women must integrate the Education 4.0 framework and the lessons learned from Singapore and Finland. In other words, the AI model must enable Afghan girls and women to thrive in the 4IR and 5IR era.

5.1 Context and Education System

[1] PAT2Math - https://github.com/patriciajaques/pat2math
https://www.mathhelp.com/
Theawise- https://thetawise.ai/demo
Flint - https://www.flintk12.com/
SchoolAI - https://schoolai.com/
K-12BERT: BERT for K-12 education - https://arxiv.org/abs/2205.12335
Rumie: https://learn.rumie.org/jR/channels/learn-with-rumie

Afghanistan ranks 146th in education, placing it among the lowest-performing systems worldwide (World Population Review, 2025). To address this challenge in a complex environment where the de facto authority actively denies Afghan girls the fundamental right to education, this research explores what lessons and insights can be drawn from high-performing systems, such as Finland and Singapore, and from PISA data and existing AI models. Furthermore, it examines how a tailored, context-specific, and advanced AI education model can be designed to meet the unique needs of Afghan girls and women.

5.2 Finland and Singapore Case Study

To address the issue of a low-performing education system and inform the design of an education model that prepares Afghan girls and women for the era of the 4IR and 5IR, this study draws on insights from two high-performing education systems: Singapore and Finland. Despite differences in their educational systems and contexts, both countries converge on key characteristics that could be generalized and adapted to Afghanistan's educational context.

Among other factors, the following key characteristics are specifically relevant to this study. First, both countries have a unified national vision that aligns education policy and resource allocation with the demands of the 4IR and 5IR. Second, both countries place strong emphasis on the real-world application of knowledge through Problem-Based Learning and project-based approaches. Finally, they put mathematics and language proficiency at the heart of education. According to Bărnuțiu-Sârca et al. (2021), the new Finnish curriculum is structured around a hybrid education approach that requires students to attain competencies in specific fields and transversal or interdisciplinary competencies. Therefore, the Finnish curriculum is designed and structured around "multiliteracy, ICT skills, and entrepreneurial skills [that] are essential for 21st century education". On the other hand, the Singapore curriculum is forward-looking and innovative, focusing on information technology, creative-critical thinking, and problem-solving skills (p. 446-447).

5.3 Programme for International Student Assessment (PISA)

Finally, PISA emphasizes mathematical, reading, and scientific literacy, as well as their application to solving real-world problems (OECD, 2023). In summary, the education curricula and AI model should be designed to incorporate insights from these cases, thereby reforming the Afghan curriculum and effectively linking education to market and economic returns. Furthermore, a forward-looking curriculum that connects education and the application of knowledge to 4IR and 5IR jobs would also help prepare Afghan girls for the General Education Development or a High School Equivalency Diploma. The ability to obtain certification would provide a pathway to higher education and enable Afghan girls and women continue their education beyond 12th Grade. Based on the comparative case study of Finland and Singapore and the PISA recommendations, the current Afghan education curricula and pedagogical approaches cannot provide a quality education that could prepare students for future opportunities. Therefore, the education system must be reformed to align it with the 4IR and 5IR.

5.4 Feasibility and Integration of AI in the Afghan Context

A recent study on the feasibility of AI for Afghan women concludes that Afghan girls and women have already adopted non-traditional education models, such as online learning, messaging services, radio, and peer-to-peer learning. The study recommends three AI education models: (1) Generative AI, (2) chatbot applications for personalized learning support, and (3) SMS-based learning. The researchers argue that the AI education model will empower Afghan girls and women (Karimy et al., 2024).

5.5 SOLAx Case Study & 21 Case Studies of AI Educational Models

SOLAx is a WhatsApp-based online education platform that provides access to learning for over 20,000 children in more than 75 countries. SOLAx has digitized Afghan school curricula using AI. To ensure accuracy and high quality, the process was supervised and verified by human experts and teachers. Now, the Afghan student can access the school curricula through its digital platform (Botti-Lodovico, 2025).

SOLAx is a WhatsApp-based online academy. "Students can access daily, asynchronous classwork in three languages (English, Pashto, and Dari) by texting the SOLAx chatbot on WhatsApp and only need a smartphone and a basic cellular connection to participate." This process includes receiving lessons and submitting assignments for evaluation and feedback. Upon completing their courses, students receive a formal certification. To access this platform, students only require a smartphone and a basic cellular connection (SOLAx, 2025).

However, three major challenges remain unresolved within the Afghan education system. First, SOLAx has not yet developed a full-scale WhatsApp AI education model that can function as a full mentor. Currently, students must use other approaches, such as online resources, peer-to-peer support, or self-study. Given the Afghan context, it is very hard for the Afghan girls and women to have access to these resources. The second challenge for the Afghan women and girls is the limited internet connectivity. According to a Gallup survey, only 6% of Afghan women have internet access, with 9% in large cities or suburbs and just 2% in rural areas (Gallup, 2023). The third challenge is the outdated Afghan education curricula and pedagogical approaches.

Addressing the limited internet connectivity problem, the development of an offline AI education model that only needs periodic updates is key. The Kolibri Education application provides students worldwide with offline access to resources, but it currently lacks an AI model that can serve as a mentor. Open-source technology and Edge AI, which uses a Raspberry Pi for a local, offline AI setup, have the potential to develop an offline, full-scale AI education model for Afghan girls with only periodic updates (ASU Next Lab, 2024).

SOLAx currently digitizes the existing Afghan school curricula, which do not address the foundational problems of an underperforming education system. A paradigm shift is required in the curricula and pedagogical approaches of the Afghan education system to prepare students for future jobs by aligning education with the skills of the future. Finally, education in Afghanistan is not yet aligned with the job market and 4IR and 5IR. Connecting education to economic returns is crucial for enabling Afghan women to achieve self-sufficiency in a rapidly changing world.

A recent World Bank study suggests that a six-week pilot of an after-school program in nine Nigerian schools, powered by generative AI (Microsoft Co-Pilot), delivered learning gains nearly

equivalent to those of two years of traditional schooling. Furthermore, a $100 investment delivered 3.2 equivalent years of schooling. Although the findings represent only one country, this study supports the learning effectiveness and cost-effectiveness of AI-powered tools when applied in combination with human intelligence and supervision (De Simone, et al., 2025).

In light of these findings, grounded in real-world examples and research, this paper proposes using open-source and Edge AI technologies to develop an offline, cost-effective AI education model. However, research indicates that existing platforms, such as Duolingo and Khan Academy's Khanmigo, use OpenAI's GPT. Adopting a similar strategy may not be sustainable in Afghanistan due to high operational costs and the requirement for high-speed internet connectivity. The costs associated with using this model could potentially be negotiated or waived for an educational project. However, internet connectivity remains a major barrier. Therefore, such a model may not be suitable for Afghanistan.

Open-source and Edge AI technologies can operate locally and offline, which helps address key barriers such as policy and cultural restrictions, poor internet connectivity, and the diverse needs of Afghan girls and women. This study recommends an offline mobile and desktop application that can function as a standalone AI education model without internet connectivity. Open-source and Edge AI technologies have the potential to inform the development of an AI education model suitable for the Afghan context. These technologies can run locally and offline, providing cost-effective alternatives to commercial APIs (ASU Next Lab, 2024).

Section 6: Conclusion

This research was inspired by the potential of the 4IR and 5IR to help Afghan girls and women achieve their full potential using an AI-powered education model. Globally, youth unemployment is rising. One of the key factors explaining this unemployment is the lack of skills required by the market (Mourshed et al., 2012). There is a disconnect between the market and education. Consequently, this study proposes a paradigm shift in the Afghan education system and curricula, responding to the needs of 4IR and 5IR, and linking education to the market and tangible economic returns.

The case studies of AI education models in this research, particularly those from Nigeria, demonstrate strong potential to support learning and education. To achieve the overarching objective of Education 4.0 and help students thrive in an era of rapid change, both the Afghan education system and curricula must be meticulously designed to integrate human and artificial intelligence. This synergy enhances both pedagogical impact and cost-efficiency (De Simone et al., 2025).

Based on the literature review, evidence, and selected case studies, AI has strong potential to help education in three areas: (1) personalized and adaptive education systems, which can address the learning poverty problem, (2) real-time assessment and feedback, and (3) automation of administrative tasks such as grading and attendance. Two AI technologies – Intelligent Tutoring Systems and Adaptive Learning Systems – were found to be the most effective. Furthermore, the

AI education model must be structured within the framework of Education 4.0 to respond to the needs of 4IR and 5IR.

This paper proposes developing a cost-effective, offline AI education model. Open-source and Edge AI technologies have the potential and adaptability for such an AI education model. Given widespread mobile access but limited internet connectivity, especially among girls and women, an offline mobile application is essential. This combination offers a cost-effective, locally run option for developing a full-scale mentorship AI model for Afghan girls and women, even without internet connectivity.

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