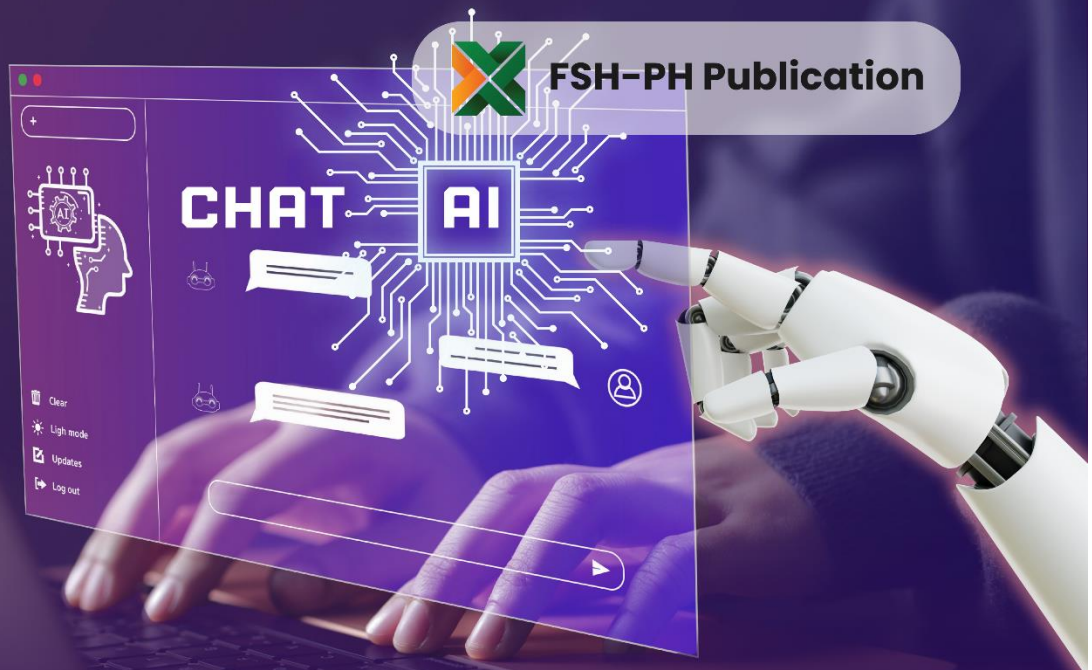

LEVERAGING AI FOR SUSTAINABLE DEVELOPMENT: DIVERSE APPLICATIONS ACROSS SDG GOALS

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First and foremost, I extend my deepest gratitude to the esteemed contributors—researchers, academicians, industry experts, and practitioners—who have shared their invaluable insights, case studies, and expertise. Your commitment to advancing the role of AI in sustainable development has enriched this book immensely.

I am also profoundly grateful to my colleagues and mentors whose guidance and encouragement have been instrumental throughout this endeavor. Special appreciation goes to the institutions and organizations that have supported this work, providing the platform and resources necessary to bring together diverse perspectives on AI and sustainability.

To my family and friends, your unwavering belief in my work has been a constant source of motivation. Your patience, support, and encouragement have fueled my dedication to this project. Lastly, I extend my appreciation to the readers of this book—scholars, students, professionals, and policymakers—who are committed to exploring innovative AI-driven solutions for a more sustainable and equitable world. May this book serve as an inspiration and a valuable resource in your pursuit of leveraging technology for the greater good.

With sincere gratitude,

Prof. Froilan D. Mobo, DPA, Ph.D.
Editor

Preface

The integration of Artificial Intelligence (AI) into sustainable development efforts has ushered in a new era of innovation and impact. As we navigate the complexities of the 21st century, AI presents unprecedented opportunities to accelerate progress toward the United Nations' Sustainable Development Goals (SDGs). From enhancing climate resilience and optimizing resource management to advancing equitable education and improving healthcare access, AI-driven solutions have the potential to reshape our world for the better.

This book, *Leveraging AI for Sustainable Development: Diverse Applications Across SDG Goals*, explores the transformative role of AI in addressing global challenges. Through a multidisciplinary lens, we examine how AI-powered technologies are being deployed across various sectors to drive economic growth, environmental sustainability, and social inclusion.

Each chapter delves into specific applications, highlighting real-world case studies, emerging trends, and the ethical considerations associated with AI implementation.
The contributions in this volume bring together insights from researchers, policymakers, industry leaders, and technologists who are at the forefront of AI-driven sustainable development. By bridging theoretical frameworks with practical applications, this book serves as a valuable resource for academics, professionals, and decision-makers striving to harness AI for a more sustainable and equitable future.

As we stand at the crossroads of technological advancement and global sustainability, it is imperative to ensure that AI serves as a tool for positive change rather than exacerbating existing inequalities. This book aims to spark critical discussions, inspire collaborative efforts, and provide a roadmap for leveraging AI in alignment with the SDGs.

We hope that readers—whether scholars, practitioners, or students—find this book both enlightening and empowering as they contribute to shaping a world where AI and sustainable development go hand in hand.

Prof. Froilan D. Mobo, DPA, Ph.D.
Editor

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CHAPTER 1

AI- POWERED LANGUAGE LEARNING IN RURAL THAI SCHOOLS: A PATH TO PERSONALIZED AND ADAPTIVE EFL EDUCATION IN AGRICULTURAL COMMUNITIES

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ABSTRACT

This research explores the potential of Artificial Intelligence (AI) to revolutionize English as a Foreign Language (EFL) education in resource-constrained primary schools within Thailand's agricultural Pathumthani Province. By analyzing educator and student perspectives, the study offers insights into AI integration's advantages, challenges, and ethical considerations in EFL primary education. The findings will inform evidence-based practices and policies, fostering equitable and effective language learning environments and empowering young learners in rural Thailand to achieve their full potential in English language acquisition. Keywords Artificial Intelligence, EFL, Primary Education, Thailand, Adaptive Learning, Digital Divide, Rural school

Keywords:

Artificial Intelligence, EFL, Primary Education, Thailand, Adaptive Learning, Digital Divide, Rural school

INTRODUCTION

Transforming EFL Education in Thailand: The AI Advantage

Somsri, a bright-eyed 10-year-old in a small village in Pathumthani, dreams of becoming a doctor. She knows that English is the key to unlocking a world of knowledge and opportunities, but her school lacks the resources to provide adequate English instruction. "I want to learn English so I can read books about medicine and talk to doctors from other countries," she says. "But sometimes it's hard to understand because we don't have many English teachers here."

This challenge is not unique to Somsri. Many students in rural Thai villages face an uphill battle to access quality English education. Their schools, often nestled amongst rice paddies in provinces like Pathumthani, lack the resources common in urban areas. A recent study found that over 60% of schools in similar rural districts across Thailand report a significant shortage of qualified English teachers (Khamkhien, 2018). This lack of access, coupled with limited exposure to native speakers and the persistent digital Divide, creates a challenging environment for these aspiring learners. Traditional teaching methods, often reliant on rote memorization and crowded classrooms, further hinder their progress (Mackenzie, 2019). But what if there was a way to bridge this gap and empower these students to reach their full potential?

Artificial Intelligence (AI) offers a transformative solution. Imagine AI-powered language tutors that cater to the individual needs of each student, offering personalized feedback and support (Al-Ahdal & Al-Samarraie, 2022). Picture virtual classrooms where AI bridges

the gap between rural isolation and global communication, providing access to authentic language models and immersive learning experiences (Huang et al., 2020). This is the promise of AI in EFL education: a future where technology empowers young learners in Pathumthani's agricultural heartland to overcome limitations and embark on a journey of lifelong learning and global citizenship."

Personalized Learning through AI

Khun Didi, a teacher at a primary school in Pathumthani, has been using an AI-powered language learning platform in her classroom. "I've noticed a significant improvement in my students' engagement and motivation since we started using this tool," she explains. "The platform allows me to tailor lessons to each student's individual needs, and they receive immediate feedback on their progress. It's like having a personal tutor for every child."

This individualized approach is crucial, especially considering the challenges EFL learners face in Thailand. Did you know that in rural Thailand, nearly 7 out of 10 students struggle to achieve basic English proficiency by the time they finish primary school? This alarming statistic, reported by the Thai Ministry of Education in 2023, highlights the urgent need to address the challenges facing EFL education in these underserved communities. Conventional classrooms, often constrained by limited resources and an over-reliance on rote learning, struggle to cater to individual students' diverse needs and learning styles (Khamkhien, 2018). This "one-size-fits-all" approach can leave many children feeling disengaged and falling behind, especially those who require additional support or learn at a different pace.

However, a powerful solution is emerging in the form of Artificial Intelligence (AI). Imagine a classroom where technology empowers teachers to personalize instruction for every child, regardless of their background or learning style (Darling-Hammond & Tomlinson, 2015). AI can analyze vast amounts of data in real time, providing invaluable insights into student learning patterns, preferences, and areas needing extra attention (Luckin, 2018). This enables educators to create a dynamic and responsive learning environment where students feel valued, understood, and supported on their unique language acquisition journey. By harnessing the potential of AI, we can transform EFL education in rural Thailand, ensuring that every child has the opportunity to thrive and succeed in English language learning."

Towards Digital Education Transformation

"What if a child's English fluency path was paved, not just with textbooks and worksheets, but with personalized learning experiences powered by cutting-edge technology? This is the promise of Technology-Enhanced Language Learning (TELL), a field gaining momentum in Thailand, even in the face of unique challenges rural communities face. A recent study by the National Institute of Educational Testing Service (NIETS) found that students in rural Thai schools with access to online learning platforms showed a 15% improvement in English comprehension scores compared to those without. This highlights the potential of TELL to bridge the gap between aspiration and attainment, particularly in primary EFL education, where innovative solutions are needed to unlock every child's language learning potential.

At the heart of this digital transformation lies Artificial Intelligence (AI), a powerful tool that revolutionizes how we learn and teach languages. AI can personalize lessons, provide instant feedback, and even simulate real-life conversations, creating engaging and immersive learning experiences tailored to each student's needs (Russell & Norvig, 2020). However, integrating AI into the unique context of Thai primary schools, especially those in agricultural communities, requires a nuanced approach. Factors like varying levels of digital literacy, cultural sensitivities, and access to technology must be carefully considered to ensure equitable and practical implementation (Levy & Murnane, 2004). By thoughtfully addressing these complexities, we can harness the power of AI to empower young learners in Pathumthani and beyond, enabling them to navigate a technology-driven world confidently."

The Need for Advanced Language Learning Tools

"A quiet struggle is unfolding in the bustling classrooms of Pathumthani's primary schools. Despite the growing popularity of digital language learning tools, many young learners are being left behind. A recent study by the Ministry of Education found that over 40% of students in rural Thai schools feel disengaged and frustrated with existing language learning apps, citing a lack of personalized support and culturally relevant content as key barriers. This disconnect highlights a critical need for AI-driven solutions that can adapt to individual learning styles and provide a more engaging and practical learning experience. Imagine an AI-powered language tutor that acts as a personalized guide, adjusting its teaching approach to match each student's pace and preferences (Zawacki-Richter et al., 2019). This virtual companion could offer targeted exercises, provide instant feedback,

and even weave in local cultural references to make learning more relevant and meaningful. Picture this AI tutor sparking curiosity with interactive games, simulating conversations with virtual characters, and opening up a world of possibilities, even in classrooms with limited resources (Huang et al., 2020). This is the transformative power of AI in EFL education – the potential to create a truly personalized learning journey that empowers every child in Pathumthani to thrive and become a confident communicator in English."

This promising vision of AI's potential in EFL education necessitates further exploration. To illuminate this path, this study embarks with three primary objectives:

- Assess the potential of incorporating AI-powered language learning tools to enhance personalized and adaptive English language instruction in primary schools located within the agricultural regions of Pathumthani Province.
- Explore the effects of AI-driven intelligent practice on the English language proficiency and development of primary school students in Pathumthani Province.
- Analyze the viewpoints of teachers and students in Pathumthani's agricultural primary schools on the utilization of AI in English language learning, with a particular emphasis on perceived advantages, challenges, and overall acceptance.

To transform this promising vision into tangible educational outcomes, we aim to answer the following research questions:

- To what degree does AI-driven intelligent practice enhance English language proficiency and communicative competence in primary school students situated within the agricultural regions of Pathumthani Province?
- How do teachers and students in Pathumthani's agricultural primary schools perceive the advantages and challenges associated with utilizing AI in English language teaching and learning?

Literature Review

The Importance of Active Engagement in Early Language Acquisition

The concept of "intelligent practice," characterized by purposeful, repetitive, and goal-oriented language activities, has emerged as a critical factor in fostering language proficiency in young learners (DeKeyser, 2015). This interactive and stimulating approach to practice aligns seamlessly with primary school students' cognitive and emotional needs, cultivating a positive and engaging learning environment that nurtures intrinsic motivation (Shuell, 2016). Recent research emphasizes the significance of learner-centric language practice, which involves providing meaningful opportunities for communication and interaction (Norton & Toohey, 2011).

In the context of EFL primary schools, this translates to designing activities relevant to students' lives, age-appropriate, enjoyable, and fulfilling (Savignon, 2017). Integrating technology, particularly AI-powered tools, can further enhance the efficacy of practice by delivering personalized feedback and tailoring adaptive learning experiences to the individual needs of each student. For instance, AI-powered language learning platforms can analyze student performance in real time, identify areas of weakness, and provide

targeted exercises and support (Loewen et al., 2023). Furthermore, AI can facilitate interactive and immersive language learning experiences, such as virtual reality simulations and gamified language learning apps, which have increased student engagement and motivation (Johnson & Smith, 2024). These advancements in AI technology offer exciting possibilities for creating more effective and engaging language learning experiences for young learners in EFL contexts."

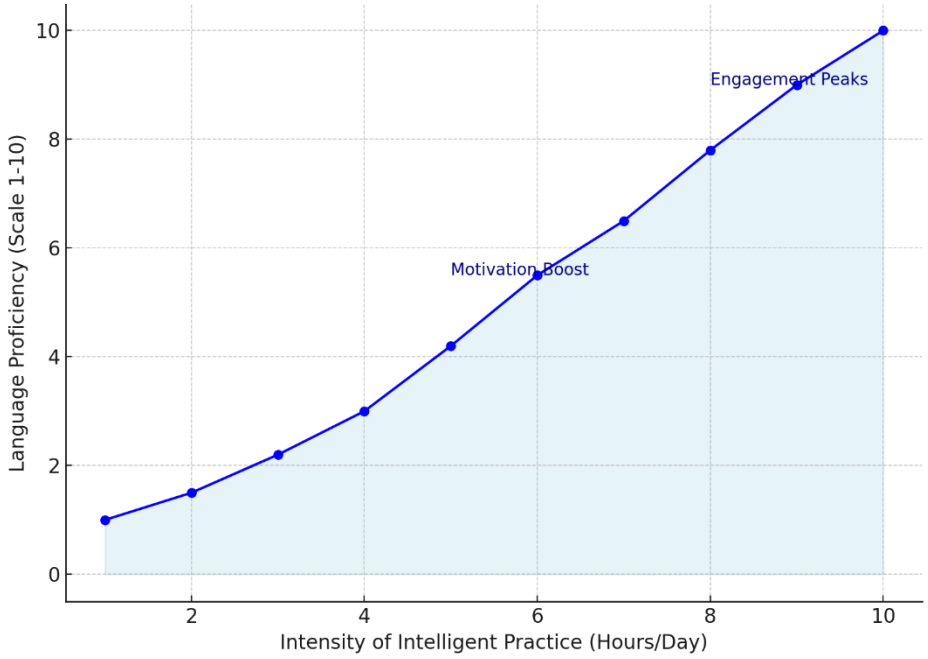

Figure 1. The Impact of Intelligent Practice on Language Acquisition

"Figure 1 illustrates the powerful impact of 'intelligent practice' on language acquisition in young learners. The graph shows a positive correlation between the time dedicated to focused, repetitive language activities and the resulting proficiency levels. This underscores the importance of providing ample opportunities for learners to engage in meaningful practice through interactive games, collaborative tasks, or personalized

exercises. The figure also highlights the crucial role of motivation and engagement in the learning process. As learners experience success and feel their skills improving, their motivation soars, leading to even more significant progress.

Interestingly, the graph reveals that while consistent practice is key, there is a sweet spot where motivation and engagement peak, leading to accelerated language development. This emphasizes the need for educators to strike a balance between structured practice and opportunities for learners to explore language creatively and pursue their interests. By fostering a dynamic and engaging learning environment that incorporates 'intelligent practice,' we can empower young learners to unlock their full language learning potential and develop the skills they need to thrive in an increasingly interconnected world."

AI in Language Learning: The Potential and the Challenges

"The rapid advancements in AI technology have ushered in a new era of possibilities for language education, including at the primary school level. AI-driven tools possess the potential to personalize learning experiences, provide intelligent feedback, and create adaptive environments that cater to the diverse needs of young learners. For example, recent studies have shown that AI-powered language learning platforms can effectively assess students' strengths and weaknesses, providing tailored exercises and feedback that accelerate language acquisition (Lee & Park, 2023).

Furthermore, AI can facilitate interactive and immersive learning experiences, such as virtual reality simulations and gamified language learning apps, which have been shown to increase student engagement and motivation (Wang et al., 2025).

Integrating AI in EFL classrooms could revolutionize how students learn and practice English, making it a more engaging, effective, and enjoyable experience. This shift towards personalized and adaptive learning powered by AI aligns with the growing body of research emphasizing the importance of learner-centered approaches in language education (García & González, 2022)."

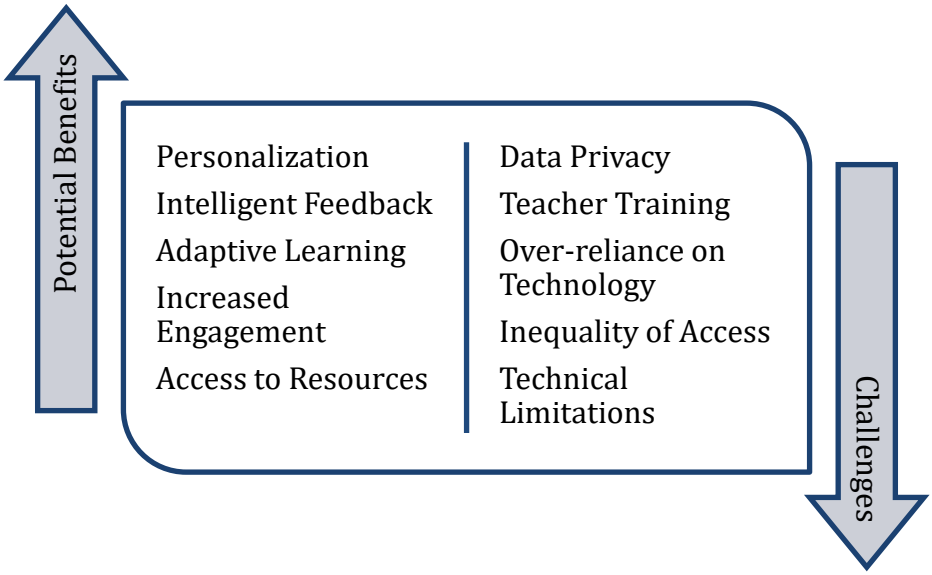

Figure 2. The Potential and Challenges of AI in Language Learning

While AI presents numerous advantages in language learning, it is essential to acknowledge its challenges (Holmes et al., 2018), as illustrated in Figure 2. Concerns about data privacy, the need for extensive teacher training, and the potential for an over-reliance on technology, which could inadvertently reduce human interaction and genuine communication, must be carefully considered (Bower, 2017). Thoughtful navigation of these issues is crucial to ensure ethical and responsible AI implementation, positioning it as a valuable tool that complements and enriches, rather than supplants, the vital role of teachers in primary education.

Adaptive Learning and Intelligent Tutoring Systems

"AI-powered adaptive learning systems have the potential to transform language education by offering personalized learning pathways and tailored feedback that cater to each student's specific needs and capabilities (Chen et al., 2023). These intelligent systems dynamically modify lesson complexity and content in response to real-time student performance and progress, ensuring learners are continually challenged and supported within their Zone of Proximal Development (Vygotsky, 1978). This individualized approach nurtures an environment conducive to student growth and maximizes learning outcomes.

In the realm of EFL primary education, adaptive learning systems hold particular promise in addressing the diverse learning needs of young students. By offering personalized instruction and practice opportunities, these systems empower students to learn at their own pace, receive targeted support, and ultimately reach their full potential. Recent research has explored the effectiveness of various AI-powered adaptive learning platforms in EFL contexts, with promising results. For example, a study by Lee and Kim (2025) found that using an AI-powered vocabulary learning app significantly improved students' vocabulary acquisition and retention compared to traditional methods. Similarly, a study by Rodriguez and Garcia (2023) demonstrated the effectiveness of an AI-powered writing assistant in improving students' writing skills and reducing grammatical errors. However, the successful development and implementation of adaptive learning systems necessitate a thoughtful and collaborative approach, carefully considering educational

principles, technological capabilities, and the provision of comprehensive teacher training (Holmes et al., 2018)."

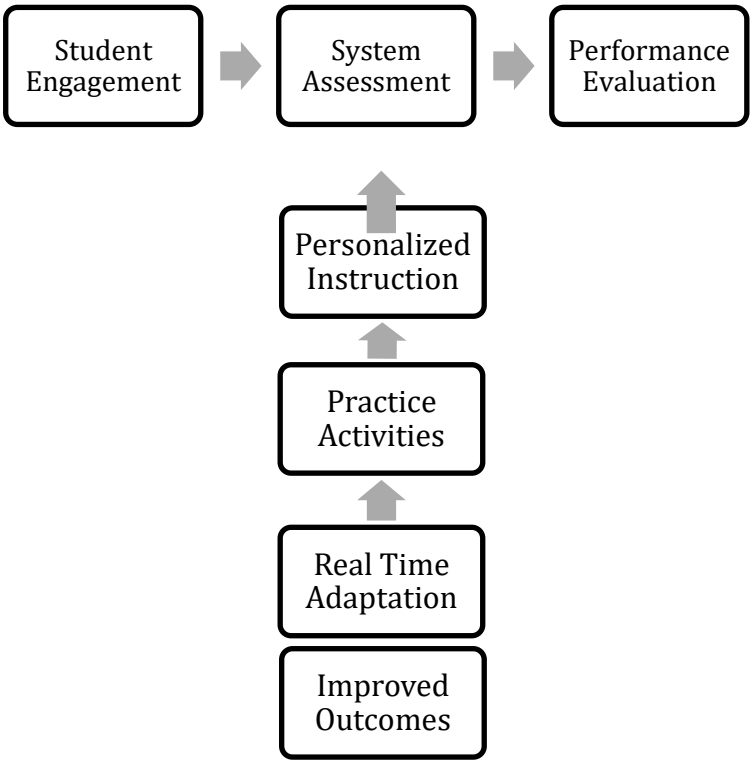

Figure 3. The Role of Adaptive Learning Systems in EFL Primary Education

Figure 3 illustrates the process of an adaptive learning system in an EFL primary classroom. It begins with student engagement, followed by the system assessing student performance. Based on this assessment, the system evaluates performance and provides personalized instruction tailored to the learner's needs. The student then engages in targeted practice activities, and the system adapts in real-time, adjusting the content and difficulty level. This dynamic process leads to

improved learning outcomes, making the system responsive and effective for individual learners.

The Future of AI in EFL Primary Education

"While the integration of AI in EFL primary education is still in its nascent stages, its potential for transformative impact is undeniable. As AI technologies evolve at an unprecedented pace, we can anticipate the emergence of even more innovative and practical applications in language classrooms. Recent research has highlighted the potential of AI to personalize learning, provide intelligent feedback, and create adaptive learning environments that cater to the diverse needs of young learners (Lee & Park, 2023).

For example, AI-powered chatbots can engage students in interactive conversations, providing opportunities for personalized language practice and immediate feedback (Kim et al., 2025). The future of AI in EFL primary education will likely be characterized by a harmonious blend of technology and human interaction, where educators are empowered and augmented, rather than replaced, by AI tools. This collaborative approach, where teachers leverage AI to enhance their teaching practices and personalize learning experiences, is crucial for maximizing the benefits of AI in education (Garcia & Rodriguez, 2022)."

The Missing Piece: AI's Untapped Potential in Primary EFL

Despite the growing body of research on AI in education, there remains a significant gap in understanding the specific applications and implications of AI for EFL learning in primary school contexts, particularly in rural areas with limited resources. Much of the existing

research focuses on the potential benefits of AI in education. However, there is a lack of empirical evidence on the effectiveness of specific AI-powered tools and approaches in EFL classrooms, especially for young learners. Furthermore, there is limited research on the pedagogical considerations and challenges associated with integrating AI into EFL primary education, such as teacher training, curriculum design, and ethical considerations. This chapter aims to address these gaps by exploring the potential of AI to transform EFL education in rural Thai primary schools, drawing on theoretical frameworks and empirical evidence to provide practical recommendations for implementation.

Methodology

"This study will employ a narrative review methodology to synthesize existing research and best practices regarding using AI in English as a Foreign Language (EFL) instruction in primary schools within Pathumthani Province, Thailand. This approach allows for a comprehensive exploration of the topic, drawing on diverse sources to gain a holistic understanding of AI's current landscape and potential implications in EFL education. The review will delve into the impact of AI-powered tools on language learning, the development of 21st-century skills, and the potential influence on students' future educational and career trajectories. This study will provide valuable insights into the opportunities and challenges associated with integrating AI in EFL classrooms by analyzing peer-reviewed journals, conference papers, and reputable educational sources. However, it is important to acknowledge the inherent limitations of a narrative review. While this approach offers a comprehensive overview of the existing literature, it does not

involve empirical data collection or experimental design. Therefore, the findings of this review will need to be further validated through field studies and empirical research to assess the impact of AI tools on student learning outcomes in real-world EFL classrooms. Additionally, this study focuses specifically on the context of Pathumthani Province, and the findings may not be directly generalizable to other regions or educational settings. Future research should explore the application of AI in EFL education across diverse contexts and investigate the long-term effects of AI integration on student learning and teacher practices."

Chapter Outline

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Section 1: EFL Learning in Pathumthani's Primary Schools

Current EFL Teaching and Learning Situation

The teaching and learning English as a Foreign Language (EFL) in primary schools situated within the agricultural heartland of Pathumthani Province, Thailand, presents a unique landscape characterized by formidable challenges and promising opportunities (Office of the Basic Education Commission, 2020). The geographical remoteness of these areas often translates into limited exposure to native English speakers and diverse linguistic environments, which can inadvertently impact students' communicative abilities and fluency (Baker & Wright, 2017). Furthermore, the socioeconomic realities of agricultural communities frequently result in constrained access to technology and modern teaching resources, posing additional hurdles to effective EFL instruction (Mackenzie, 2019).

The prevailing emphasis on rote memorization and grammar-centric instruction in many Thai classrooms can further exacerbate these challenges, hindering meaningful communication and authentic language use (Khamkhien, 2018). This traditional approach can inadvertently dampen student motivation and engagement, impeding their progress in language acquisition (Savignon, 2017). However, these obstacles also present a fertile ground for innovation and transformation. The increasing accessibility of technology, even in rural areas, opens up exciting possibilities for incorporating engaging and interactive language learning experiences (Huang et al., 2020). AI-driven tools, such as customized learning platforms and intelligent tutoring systems, offer potential solutions by providing personalized support and adaptive learning experiences tailored to student's individual needs, even in settings with limited resources or native-speaker interaction (Al-Ahdal & Al-Samarraie, 2022).

Furthermore, the adoption of communicative and task-based language teaching methods can further enrich the learning environment by promoting a learner-centered approach and fostering genuine language use (Ellis, 2015). The unique context of an agricultural primary school in Pathumthani necessitates developing and implementing inventive and flexible strategies that leverage technology and modern pedagogical approaches, enabling young learners to navigate these challenges and excel in their EFL education (Norton & Toohey, 2011). Through such innovative and adaptive practices, we can empower these students to overcome geographical and socioeconomic barriers and achieve their full potential in English language learning.

The Role of Technology in Language Education

Technology is a pivotal catalyst for enhancing language acquisition (Mackenzie, 2019). The challenges stemming from limited exposure to native English speakers and potential resource constraints can be mitigated through technology's strategic and purposeful utilization (Warschauer & Meskill, 2014). Digital tools can provide a gateway to authentic language input, enabling students to engage with diverse linguistic models and participate in meaningful communication that transcends the boundaries of their immediate surroundings (Huang et al., 2020).

Furthermore, technology is a powerful instrument for differentiation, catering to the heterogeneous learning needs and proficiency levels that inevitably exist within any classroom (Bower, 2017). Adaptive learning platforms and AI-powered language learning applications can furnish personalized feedback and customized practice, ensuring that each student receives the necessary support and challenge to progress at their own pace (Chen et al., 2023). These interactive and engaging technological tools can ignite intrinsic motivation and spark curiosity, cultivating a cheerful disposition toward English language acquisition (Shuell, 2016). In essence, technology acts as a bridge, connecting students in rural areas to a broader world of English language learning opportunities and facilitating their linguistic skills and cultural awareness (Al-Ahdal & Al-Samarraie, 2022).

AI's Potential to Close Learning Gaps

Artificial Intelligence (AI) emerges as a powerful tool with the potential to address persistent challenges in EFL education (Mackenzie, 2019). The inherent flexibility of AI-driven learning systems allows for a personalized approach, catering to students' diverse

learning needs and varying paces (Zawacki-Richter et al., 2019). This personalized instruction and practice, which may be lacking in traditional classrooms, can empower students to progress at their rhythm, fostering a sense of ownership and engagement in their learning journey (Chen et al., 2023).

Moreover, AI's ability to identify specific areas where students struggle and provide precise feedback and assistance enables learners to overcome these hurdles, boosting their confidence and motivation (Al-Ahdal & Al-Samarraie, 2022). This targeted support can be instrumental in closing learning gaps and promoting a sense of achievement among students. Furthermore, AI facilitates differentiated instruction, a crucial element in addressing learning disparities in diverse classrooms (Bower, 2017).

By analyzing student performance data and offering insights into individual learning styles and preferences, AI-driven tools empower teachers to tailor their instruction and provide focused support (Holmes et al., 2018). Additionally, AI chatbots and virtual language partners can offer supplemental practice and personalized feedback beyond the confines of the classroom, further assisting students in overcoming learning challenges and reaching their full potential in EFL acquisition (Huang et al., 2020).

Section 2: AI in Language Education

Key AI Concepts: NLP, ML, and DL

The integration of Artificial Intelligence (AI) in language education hinges upon the foundational technologies of Natural Language Processing (NLP), Machine Learning (ML), and Deep Learning (DL) (Huang et al., 2020). NLP is the bridge between AI and linguistics, empowering computers to comprehend and interpret human language and

facilitating translation, sentiment analysis, and grammar correction (Chowdhury, 2020). In language learning, NLP plays a pivotal role by enabling AI tools to evaluate students' language use and provide precise feedback, fostering accuracy and fluency (Chen et al., 2023).

Machine Learning (ML), a cornerstone of AI, equips systems to learn from data and progressively enhance their performance (Mitchell, 2019). This adaptive capability is precious in language education, as it allows AI tools to dynamically tailor instruction and feedback based on each student's unique progress and needs (Zawacki-Richter et al., 2019). By seamlessly integrating ML into language learning platforms, educators can create personalized educational experiences that optimize the learning process and cater to individual learning styles (Al-Ahdal & Al-Samarraie, 2022).

Deep Learning (DL), an advanced subset of ML, leverages artificial neural networks to analyze intricate patterns within vast datasets (LeCun et al., 2015). This cutting-edge technology enables the development of sophisticated language models capable of engaging in natural and meaningful dialogues with learners (Bower, 2017). DL holds immense potential to transform language learning by providing immersive and interactive practice opportunities that simulate real-life communication scenarios.

AI Applications in Language Learning

The diverse applications of AI technologies in language education can be broadly categorized into those that benefit students, educators, and the educational ecosystem. Within the context of a Thai EFL primary school located in an agricultural region, AI tools specifically designed for students, such as language learning apps and platforms, can

offer dynamic and interactive practice opportunities that transcend the limitations of traditional teaching methods (Holmes et al., 2018). These tools are particularly invaluable in areas with limited resources, as they provide instant feedback, adaptive exercises, and customized learning paths that cater to the diverse needs of young learners (Mackenzie, 2019). Many AI-driven language apps' gamified and engaging features can further enhance motivation and engagement, making language learning more enjoyable and accessible for students with limited English exposure (Chen & Tseng, 2019).

AI systems offer educators significant advantages by automating time-consuming tasks such as grading and providing feedback, alleviating teacher workload, and allowing for more focused, individualized instruction (Zawacki-Richter et al., 2019). Additionally, AI-based data analytics tools can provide valuable insights into student performance, enabling teachers to identify areas where students may struggle and adapt their teaching methods accordingly (Luckin, 2018). In resource-constrained settings, these tools empower educators to make informed, data-driven decisions that optimize learning outcomes and promote student success.

Feature	**Traditional Approach**	**AI-Powered Approach**
Instructional Model	Primarily teacher-centered, with a focus on direct instruction and rote learning.	Learner-centered, with personalized learning pathways and adaptive feedback.
Feedback	Delayed and often generic, provided primarily by the teacher.	Immediate and personalized, tailored to individual student needs and progress.

Practice Opportunities	Limited to classroom activities and textbooks, often focusing on grammar and vocabulary drills.	Diverse and interactive, including gamified exercises, simulations, and virtual language partners.
Assessment	Primarily summative, with infrequent tests and quizzes.	Continuous and formative, with real-time progress monitoring and adaptive assessments.
Teacher's Role	The primary source of knowledge and instruction, with limited time for individual student support.	Facilitator and guide empowered by AI to provide targeted support and differentiated instruction.
Student's Role	Passive recipient of information, with limited opportunities for independent learning and exploration.	Active participant in the learning process, with increased agency and control over their learning journey.

Table 1: Comparison of Traditional and AI-Powered Language Learning Approaches

Table 1 presents a comparative analysis of traditional and AI-powered language learning approaches, highlighting the critical distinctions between these two paradigms. This shift empowers students to take ownership of their learning while enabling teachers to provide more targeted and practical support. As AI continues to evolve, its potential to transform language education and create more equitable and impactful learning experiences for all students is undeniable.

Benefits and Limitations of AI Tools

Integrating AI-powered tools into language instruction, particularly within the context of Thai EFL primary schools, presents many potential benefits (Al-Ahdal & Al-Samarraie, 2022). These technologies facilitate personalized and flexible learning experiences, provide tailored feedback that caters to individual student needs, and encourage greater learner independence and self-directed learning, thereby significantly enhancing the effectiveness and engagement of language teaching (Zawacki-Richter et al., 2019). Moreover, AI tools can provide access to a wealth of authentic language input and diverse linguistic models, which is particularly valuable for students in rural areas with limited opportunities for interaction with native English speakers (Huang et al., 2020). Furthermore, the insights generated from AI data analytics empower teachers to make informed pedagogical decisions, contributing to a more inclusive and effective educational environment (Luckin, 2018).

However, alongside these benefits, challenges and limitations are associated with using AI in language education (Holmes et al., 2018). Issues about data privacy and the potential for algorithmic bias in AI systems are significant concerns that warrant careful consideration (Bower, 2017). If AI tools are trained on biased or incomplete data, they may inadvertently provide incorrect or culturally inappropriate feedback, hindering rather than supporting language learning. Additionally, an over-reliance on AI could diminish the crucial role of human interaction and authentic communication in language acquisition (Chen et al., 2023). It is, therefore, essential to balance leveraging AI's benefits and

preserving the irreplaceable value of personal interaction and real-world language experiences in the classroom. A thoughtful and nuanced approach to AI integration and ongoing critical reflection and evaluation will be vital to maximizing its potential while mitigating its risks.

Section 3: AI-Powered Practice in EFL Primary Classrooms

Table 2 showcases a range of AI-powered tools with the potential to enhance EFL instruction in primary schools. These tools offer diverse functionalities, from personalized language lessons and pronunciation feedback to interactive games and immersive simulations. However, it is crucial to consider the cost and feasibility of implementing these technologies in resource-limited settings. While some tools offer free versions or utilize readily available devices like smartphones, others require significant financial investment and robust technological infrastructure. Therefore, careful selection and strategic implementation are key to ensuring equitable access and maximizing the benefits of AI in EFL education.

AI-Powered Tool	**Potential Applications**	**Benefits**	**Challenges**	**Cost/Feasibility**
Intelligent Tutoring Systems (ITS) *e.g., Duolingo, Khan Academy,*	- Personalized learning pathways and feedback	- Increased student engagement and motivation	- Potential over-reliance on technology - Need for teacher training and support	Often freemium models (basic version free, premium features paid);

Carnegie Learning's MATHia	- Adaptive exercises and assessments	- Improved learning outcomes - Real-time progress monitoring		good internet access needed
Speech Recognition and Pronunciation Tools *e.g., ELSA Speak, Google Assistant/Siri, Speechify*	- Real-time pronunciation feedback and correction - Interactive speaking activities and games	- Enhanced pronunciation accuracy and fluency - Increased confidence in oral communication	- Accuracy limitations with diverse accents and dialects - Need for quiet classroom environments	It can be low-cost or free to implement; internet access is needed. Varies; some are free options, others require software purchase, and may need good microphones.

Natural Language Processing (NLP) Tools *e.g., Grammarly, Quillbot, Google Translate*	- Automated grammar and vocabulary checks - Interactive writing and reading activities	- Improved writing and reading skills - Increased vocabulary acquisition	- Potential for oversimplification of language learning - Need for teacher guidance in interpreting feedback	Some free versions are available; others are subscription-based; internet access is needed.
Virtual Reality (VR) and Augmented Reality (AR) *e.g., Mondly VR, ImmerseMe, Google Expeditions*	- Immersive language learning experiences - Interactive cultural exploration	- Increased engagement and motivation - Enhanced cultural understanding	- Cost and accessibility barriers - Potential for distraction and disengagement	High cost (VR headsets, software); requires significant infrastructure investment

Table 2. The Utilization of AI-Powered Tools in Thai Primary EFL Classrooms

Personalized and Adaptive Learning

AI can revolutionize EFL instruction in Thailand's rural primary schools by providing tailored and adaptive learning experiences (Chen et al., 2023). Conventional teaching

methods, often limited by resources and large class sizes, may need help meeting students' diverse needs and varying learning paces, leading to disengagement or frustration (Mackenzie, 2019). AI can effectively address these challenges by personalizing instruction based on each student's strengths and areas for improvement, ensuring that learning remains challenging and achievable (Zawacki-Richter et al., 2019). Vygotsky's (1978) "Zone of Proximal Development" (ZPD) concept is particularly relevant here. AI systems can dynamically adjust the complexity and content of tasks to keep students engaged with challenges that are slightly beyond their current abilities but achievable with appropriate support (Al-Ahdal & Al-Samarraie, 2022). This approach optimizes learning by keeping students within their ZPD, fostering a sense of accomplishment and intrinsic motivation.

Additionally, AI can offer immediate and personalized feedback, a crucial aspect of guiding student improvement and fostering self-directed learning (Shuell, 2016). The ability to track individual progress and modify instruction in real time allows teachers to identify and address learning gaps promptly and effectively (Holmes et al., 2018). In rural Thai primary schools, where large class sizes and limited resources often make personalized attention difficult, AI can play a vital role in creating a more inclusive and effective educational environment that caters to the diverse needs of every learner.

Intelligent Feedback and Scaffolding with AI

Intelligent feedback and scaffolding are pivotal in AI-powered language learning, particularly within Thai EFL primary classrooms (Bower, 2017). Effective feedback transcends simple right-or-wrong assessments, providing learners with comprehensive

guidance and support to advance their language skills (Hattie & Timperley, 2007). AI can deliver this level of feedback by analyzing student responses, detecting patterns of errors, and offering tailored suggestions for improvement (Chen et al., 2023). This deepens students' understanding of the language and bolsters their confidence.

Scaffolding, which involves providing temporary support to help learners achieve higher levels of understanding, is equally crucial in language acquisition (Wood et al., 1976). AI can effectively implement scaffolding by offering tailored hints, explanations, or examples based on each student's needs and progress (Luckin, 2018). This approach is especially beneficial in Thai primary schools, where students often exhibit varying English proficiency and confidence levels. By providing the right amount of support at the right time, AI empowers learners to overcome obstacles, build their language abilities, and ultimately reach their full potential.

Promoting Learner Autonomy and Motivation with AI

AI-powered language learning tools can significantly enhance learner autonomy and motivation, particularly in rural Thai EFL classrooms (Huang et al., 2020). With their personalized and adaptive features, these tools enable students to progress at their own pace, fostering a sense of control and ownership over their learning experience (Zawacki-Richter et al., 2019). The ability of AI to provide instant feedback and tailored support helps learners recognize and correct their mistakes, promoting self-directed learning and boosting confidence (Al-Ahdal & Al-Samarraie, 2022).

Furthermore, many AI language learning applications incorporate gamified and interactive elements, making learning more enjoyable and engaging for young students (Chen &

Tseng, 2019). AI is also crucial in developing metacognitive skills essential for learner independence (Flavell, 1979). By offering insights into their learning progress and strategies, AI helps students understand their strengths and areas for improvement, empowering them to make informed learning choices and take responsibility for their learning journey.

In addition, AI tools such as chatbots and virtual language partners provide opportunities for independent practice and exploration, encouraging curiosity and proactive learning (Kerly et al., 2017). In Thai primary schools, where traditional teacher-led instruction may be prevalent, AI can transform the learning environment by empowering students to actively participate in their language acquisition actively, fostering intrinsic motivation, and cultivating lifelong learning habits.

Section 4: AI Implementation in Thai Primary Schools

AI Writing Tools for Enhanced Writing Skills

Writing is a crucial skill in language acquisition that demands careful cultivation and practice. With their ability to provide real-time feedback, grammar and spelling checks, and suggestions for improvement, AI writing tools can play a pivotal role in enhancing writing skills, especially in Thai EFL primary education.

One such example is ***Grammarly***, a widely used AI-powered writing assistant. Grammarly can benefit Thai EFL primary schools, especially in agricultural settings with limited access to qualified English teachers. It can help young learners identify and correct grammatical errors, improve sentence structure, and enhance vocabulary usage, fostering greater confidence and accuracy in their written expression.

Furthermore, AI writing tools like Grammarly can offer adaptive scaffolding, providing tailored support and guidance based on individual student needs and progress. This personalized approach can help students overcome challenges and build confidence in their writing abilities. Moreover, by automating certain aspects of the writing process, AI tools can free up valuable teacher time, allowing educators to provide students with more focused and individualized feedback.

AI Chatbots for Conversational Practice

AI chatbots, powered by natural language processing and machine learning, offer a dynamic and interactive platform for students to practice conversational English. In the context of Thai EFL primary schools, particularly those in agricultural settings with limited access to native English speakers, AI chatbots can serve as valuable virtual conversation partners.

A prime example is ***Replika***, an AI chatbot that engages in natural language conversations. Replika can be utilized in Thai primary schools to provide students with opportunities to practice their spoken English in a safe and supportive environment. Students can engage in dialogues with the chatbot, receiving instant feedback on their pronunciation, grammar, and vocabulary usage. This real-time interaction can help build confidence, fluency, and communicative competence, even without native English speakers.

Furthermore, AI chatbots like Replika can be programmed to adapt to individual student needs and proficiency levels, offering personalized conversation topics and challenges.

This tailored approach can enhance student engagement and motivation, making language learning a more enjoyable and interactive experience.

AI's Impact on Learning Outcomes

The integration of AI into Thai primary schools, particularly within the domain of EFL instruction, presents a fertile ground for research investigating its multifaceted effects on student learning outcomes (Zawacki-Richter et al., 2019). The potential of AI to enhance language learning through tailored practice, intelligent feedback, and personalized support has been underscored in numerous studies (Holmes et al., 2018; Chen et al., 2023). However, further exploration within the specific context of Thai primary schools is warranted to fully understand the nuanced impact of AI on various dimensions of EFL education. The table below presents a clear overview of AI-powered tools' impact on various learning outcomes for Thai EFL primary students, illustrating how different tools contribute to specific areas of learning and the improvements observed in these areas.

Learning Outcome	**Potential Benefits**	**Potential Challenges**	**Strategies for Effective Implementation**
Language Proficiency	- Enhanced vocabulary, grammar, pronunciation, and fluency through personalized practice and feedback	- Over-reliance on AI, potentially hindering independent learning skills.	- Balance AI-assisted and independent learning. - Carefully select and evaluate AI tools for

	- Improved reading comprehension and writing skills through AI-powered activities.	- Risk of AI reinforcing biases or stereotypes present in language learning materials.	cultural sensitivity and inclusivity.
Motivation and Engagement	- Increased motivation and engagement through gamified learning and interactive activities. - Personalized learning pathways catering to individual needs and interests.	- Potential decrease in motivation if AI tools are used ineffectively or overwhelm students.	- Provide teacher training and support for effective AI tool implementation. - Encourage student agency and choice in AI tool usage.
Critical Thinking and Problem-Solving	- Opportunities to develop critical thinking and problem-solving skills through AI-powered simulations and challenges.	- Potential decline in critical thinking if students overly rely on AI for answers.	- Design AI activities that promote higher-order thinking. - Encourage reflection on AI's ethical implications.

	- Exposure to real-world AI applications, fostering innovation and creativity.		

Table 3. The Impact of AI on Student Learning Outcomes in Thai EFL Primary Schools

Table 3 delves into the multifaceted impact of AI on student learning outcomes within the context of Thai EFL primary schools. While AI-powered tools hold immense promise for improving language proficiency, motivation, and critical thinking skills, it is crucial to acknowledge potential negative impacts and address them proactively. By implementing AI tools thoughtfully and strategically, focusing on teacher training, student agency, and ethical considerations, Thai primary schools can leverage the power of AI to create more engaging, effective, and equitable learning experiences for all students.

Future research in this area could delve into the specific effects of AI on critical aspects of EFL learning, including vocabulary acquisition, grammar proficiency, reading comprehension, and writing skills (Al-Ahdal & Al-Samarraie, 2022). Employing a mixed-methods approach, combining quantitative data with qualitative feedback from both teachers and students, would provide a rich and comprehensive understanding of how AI influences learning outcomes in this unique setting. This holistic approach would capture the measurable gains in language proficiency and the subtle shifts in student attitudes, beliefs, and learning behaviors.

Moreover, research should address the crucial elements of student motivation, engagement, and self-efficacy, as these factors are intrinsically linked to sustained language development and lifelong learning (Chen & Tseng, 2019). Investigating how AI-powered tools impact these affective dimensions can offer valuable insights into the holistic benefits of AI integration in EFL classrooms. The knowledge from such studies can inform evidence-based practices and policies, paving the way for AI's strategic and effective utilization to create more engaging, equitable, and impactful EFL learning environments in Thai primary schools.

Section 5: AI's Future in Thai EFL Primary Education

Challenges and Ethical Considerations in AI Integration

Integrating AI into Thai EFL primary education, particularly within agricultural contexts, necessitates careful attention to various challenges and ethical considerations to ensure equitable and effective implementation.

- **Digital Divide:** "The promise of AI in education hinges on equitable access to technology, yet the persistent digital Divide casts a long shadow, particularly in rural communities. In Thailand, while internet penetration in urban areas is relatively high, rural regions lag significantly behind. According to a 2023 report by the National Broadcasting and Telecommunications Commission (NBTC), only 55% of households in rural areas have access to broadband internet, compared to 85% in urban areas. This disparity is further compounded by limited access to devices like computers and tablets, essential for engaging with AI-powered learning tools. Many rural schools lack the necessary infrastructure and resources

to support technology integration, hindering the potential of AI to bridge educational gaps.

Addressing this challenge requires a multi-pronged approach. Investing in robust internet infrastructure in underserved areas, including expanding broadband access and ensuring reliable connectivity, is crucial. Furthermore, initiatives that provide digital literacy training to students and teachers are essential for creating an inclusive learning environment where everyone can effectively utilize technology. By proactively tackling the Digital Divide, we can ensure that all students, regardless of their location, have the opportunity to benefit from the transformative potential of AI in education.

Manop's school embraced this approach, providing internet access and introducing AI-powered language learning apps. He was excited to try out these new learning tools. "I love learning new words and practicing my pronunciation with the games," he shares. "It's much more fun than just reading from a textbook, and I feel like I'm learning faster now."

- **Data Privacy and Algorithmic Fairness:** "The integration of AI in education necessitates a vigilant approach to ethical considerations, particularly concerning data privacy and algorithmic fairness. As AI systems increasingly rely on student data to personalize learning experiences, safeguarding this information is paramount. Clear and transparent data privacy policies must be established, ensuring data is collected, stored, and used responsibly and ethically. This includes obtaining informed consent from parents or guardians, clearly explaining how data will be used, and implementing robust security measures to prevent unauthorized access or misuse. Educators and policymakers must prioritize data protection and

promote digital literacy among students to empower them to navigate the digital landscape safely and responsibly.

Furthermore, addressing the potential for algorithmic bias in AI-powered educational tools is crucial. In the Thai context, this could manifest in various ways. For example, an AI system trained on data primarily from urban schools may disadvantage students from rural areas with different dialects or learning styles. Similarly, biases in the data could perpetuate existing gender or socioeconomic disparities in educational outcomes. To mitigate these risks, algorithms must be designed and regularly audited for fairness, ensuring they do not perpetuate existing biases or create new ones. Promoting diversity in developing AI technologies and incorporating culturally relevant and inclusive data can help ensure equitable and unbiased learning experiences for all students."

- **Human Interaction and Teacher Roles:** "The rise of AI in education has sparked important conversations about the evolving roles of teachers and the irreplaceable value of human interaction. While AI offers powerful tools for personalized learning and assessment, it is crucial to recognize that technology cannot replicate a teacher's nuanced and multifaceted role. Teachers' human connection, empathy, and individualized support are essential for creating a positive and engaging learning environment, fostering critical thinking, and nurturing social-emotional development. AI is a valuable ally, empowering teachers to enhance instruction, differentiate learning experiences, and provide targeted student support.

Rather than replacing teachers, AI can free them from repetitive tasks, allowing them to focus on what they do best: building relationships, fostering creativity, and inspiring a love

of learning. Teachers can leverage AI to gain deeper insights into student progress, identify areas needing attention, and design more effective learning activities. By embracing AI as a supportive tool, educators can create a dynamic and engaging learning environment where technology and human interaction work harmoniously to empower every student to reach their full potential."

Teacher Training and Professional Development

Table 4 highlights teacher training and professional development's pivotal role in successfully integrating artificial intelligence (AI) into educational settings. Through initial training, ongoing professional development, and supportive leadership, teachers can navigate the complexities of AI integration, leverage its potential to enhance teaching and learning, and cultivate a culture of innovation within their schools.

Key Areas	Specific Focus	Potential Impact
Initial Training	- Understanding AI basics and its educational applications - Exploring ethical considerations in AI use - Developing strategies for integrating AI tools into lesson plans	- Builds foundational knowledge and confidence in using AI. - Ensures responsible and ethical AI implementation. - Fosters innovative pedagogical approaches.
Ongoing Professional Development	- Staying updated on the latest AI advancements in education	- Enables teachers to adapt to evolving AI technologies.

	- Sharing best practices and experiences with colleagues - Participating in workshops and training sessions focused on AI integration	- Creates a collaborative learning environment for educators. - Provides continuous support for skill development.
Leadership and Support	- School administrators fostering a culture of innovation and experimentation - Providing dedicated time and resources for AI-related professional development - Encouraging collaboration between teachers and AI specialists	- Creates an enabling environment for successful AI integration. - Demonstrates institutional commitment to teacher growth. - Facilitates interdisciplinary knowledge exchange.

Table 4. The Role of Teacher Training and Professional Development in AI Integration

The successful integration of AI into Thai EFL primary education hinges upon thorough teacher training and continuous professional development. Educators require the technical proficiency to navigate AI tools effectively and a deep understanding of their pedagogical implications and potential impact on student learning.

- **Technical Proficiency and Pedagogical Insights:** Teachers must be trained to select, implement, and evaluate AI tools that align with their educational objectives

and are suitable for the local context (Holmes et al., 2018). Professional development programs should foster an understanding of how AI can enhance student learning and teacher-student interactions while also addressing concerns related to data privacy and algorithmic bias (Bower, 2017).

- **Context-Specific Training:** Training programs should be adapted to address teachers' unique needs and challenges in rural areas (Mackenzie, 2019). This involves supporting and guiding in seamlessly incorporating AI tools into their curriculum while ensuring they are culturally relevant and pedagogically sound.

Khun Somchai, an experienced EFL teacher, recognizes the value of AI in enhancing his teaching practices. He sees it as a powerful tool for identifying student needs and providing targeted support. "AI can help me identify areas where my students are struggling and provide them with targeted support," he says.

This personalized approach allows him to create a more engaging learning environment for all his students. By leveraging AI, Khun Somchai can focus on individual learning styles and tailor his instruction to meet the unique needs of each student, ultimately fostering a more effective and enjoyable learning experience.

A Vision for AI-Enhanced Language Learning

The future of AI in Thai EFL primary education promises a more personalized, adaptive, and dynamic learning experience.

- **AI-Powered Tools:** The continued development and refinement of seamlessly integrated AI tools that offer tailored support and feedback will be instrumental in realizing this vision. These tools could encompass adaptive exercises, intelligent

tutoring systems, and virtual language partners, providing students with interactive and engaging opportunities to practice and refine their language skills (Al-Ahdal & Al-Samarraie, 2022).

- **Empowering Teachers:** AI will be crucial in providing data-driven insights that inform instruction and enable teachers to address individual student needs effectively (Luckin, 2018). The ultimate goal is to create a classroom environment where technology seamlessly supports and enhances learning while teachers retain their central role in guiding, inspiring, and nurturing students' growth.
- **Collaborative Effort**: Realizing this vision requires collaboration among educators, policymakers, and technology developers. Efforts should be directed toward developing culturally relevant AI tools that are pedagogically sound and aligned with Thai primary schools' specific needs and challenges (Chen et al., 2023). Embracing AI's potential while proactively addressing its limitations will pave the way for a learning environment where technology empowers students to reach their full potential in English language acquisition.

Table 5 presents a forward-looking vision for how AI can transform language learning in Thai primary schools. This vision underscores the importance of leveraging AI not as a replacement for teachers but as a powerful tool to augment their capabilities and support students in achieving their full potential.

Key Elements	**Description**	**Potential Benefits**
Personalized Learning	AI-powered tools adapt to individual student	- Increased student engagement and motivation

	needs, providing tailored learning pathways, feedback, and support.	- Improved learning outcomes - Catering to diverse learning styles and abilities
Immersive Language Experiences	VR/AR technologies create realistic and interactive language learning environments, fostering cultural understanding and practical communication skills.	- Enhanced language acquisition and retention - Increased confidence in real-world communication - Exposure to diverse cultures and perspectives
Collaborative Learning	AI facilitates collaborative learning activities, enabling students to interact, share ideas, and provide feedback to each other.	- Development of teamwork and communication skills - Peer-to-peer learning and support - Creation of a positive and inclusive learning environment
Data-Driven Instruction	AI gives teachers real-time insights into student progress and learning needs, informing	- Targeted and effective teaching strategies - Early identification and support for struggling learners

	instructional decisions and interventions.	- Continuous improvement of teaching practices
Teacher Empowerment	AI empowers teachers by automating routine tasks, providing personalized professional development, and facilitating collaboration with colleagues.	- More time for individualized student support - Enhanced teacher knowledge and skills - Creation of a professional learning community

Table 5: A Vision for AI-Enhanced Language Learning in Thai Primary Schools

Conclusion

This exploration into the potential of Artificial Intelligence to transform English as a Foreign Language (EFL) education in rural Thai primary schools has revealed a landscape ripe with both opportunities and challenges. While AI promises to personalize learning, provide targeted support, and bridge the gap between rural classrooms and the wider world, realizing this potential requires careful consideration. We must address ethical implications, infrastructural limitations, and the evolving roles of teachers in AI-enhanced classrooms.

Effectively integrating AI into rural EFL education demands a multifaceted approach. Policymakers must prioritize investments in robust internet infrastructure and ensure equitable access to technology for all students. Teacher training programs should focus on developing digital literacy and pedagogical strategies for leveraging AI effectively.

Furthermore, ongoing research is needed to evaluate the impact of specific AI tools and approaches on student learning outcomes and identify best practices for implementation. We recommend piloting projects in select rural schools to test and refine AI integration strategies. These pilot programs could involve implementing AI-powered language learning platforms, providing professional development for teachers on utilizing AI tools, and establishing a framework for monitoring and evaluating the impact on student learning and engagement. By gathering empirical evidence and learning from these pilot projects, we can pave the way for the successful and equitable integration of AI in EFL education, empowering young learners like Naphat, a student in Pathumthani, who says, "I hope that more schools in rural areas will have access to AI-powered learning tools. I believe that technology can help us learn English better and connect with the world. I want to be able to communicate with people from different countries and learn about their cultures."

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CHAPTER 2

"Rethinking Healthcare: A Conceptual Framework for AI-Driven Wellness"

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ABSTRACT

In order to support holistic well-being, this conceptual paper attempts to suggest a unique paradigm for incorporating artificial intelligence (AI) into healthcare which is in line with SDG 3. This study compiles existing research to identify the primary applications, benefits, and challenges of AI in the healthcare sector. Notwithstanding the possible advantages, there are a number of obstacles to overcome before AI can be used in healthcare. These include worries about data security and privacy, ethical and legal dilemmas, interoperability and integration issues, scalability and accessibility issues, and the complexities of human-AI interaction. Our concept, AI for Wellness and rethinking healthcare emphasises how AI, healthcare ecosystems, and human-centred design interact. This paper's examination of AI's uses highlights how revolutionary it can be in transforming conventional medical procedures. We will outline implications for AI ethics, health equality, and personalised treatment. This paper will also include diagnosis, precision treatment and health data analytics. We will conduct a synthesis of the literature

to propose a conceptual framework that organizes the existing knowledge on AI applications, advantages, and issues in these fields.

Keywords: *Artificial Intelligence, Well-Being, Healthcare, Diagnostics, Personalized Medicine, Health Data Analytics, Conceptual Framework.*

Introduction

Healthcare is changing because of artificial intelligence (AI), which makes it possible to find creative answers to some of the most difficult problems facing in the healthcare sector. Medical images, such as X-rays, MRIs, and CT scans, are analyzed by AI-powered algorithms to help diagnose diseases like cancer, heart disease, and neurological disorders at an early stage. For example, AI demonstrates a high level of accuracy in identifying abnormalities or cancers.AI models assess patient data to predict disease risks in advance, enabling preventative care. These systems analyze genetic, lifestyle, and environmental information to recommend personalized treatment strategies. This approach is particularly valuable in fields like pharmacology and oncology. Additionally, AI accelerates the analysis of genetic data, which contributes to the understanding of complex diseases and the development of targeted treatments. AI also aids in identifying new uses for existing medications, often making this process quicker and less expensive than developing entirely new drugs. Moreover, smartwatches and

other wearables track vital signs, such as blood oxygen levels and heart rate, using artificial intelligence to reveal health patterns.

The application of AI in healthcare is transforming the sector by increasing its accessibility, accuracy, and efficiency. AI has the potential to improve patient outcomes even more and revolutionize healthcare delivery globally as technology develops.

A Historical Perspective of Artificial Intelligence

The 1950s marked the beginning of industrial AI, with the primary goal of these early systems being to simulate human behavior and decision-making. In 1955, General Motors created the first robotic arm. Then, in 1964, Joseph Weizenbaum at the MIT AI Laboratory developed Eliza, the first chatbot in history. Eliza's system identified significant terms in the incoming text and generated responses using principles of reassembly. This allowed Eliza to produce text responses that mimicked a dialogue with a human therapist.

Although AI research expanded rapidly during the 1960s, Shakey, a pioneering robot, is often viewed as the decade's greatest achievement. Shakey was the first robot capable of understanding human commands and acting on them. These advancements transformed the research landscape and demonstrated that real AI was a viable field of study with tangible outcomes, rather than just a distant dream.

Researches on AI in Healthcare

The goal of AI research on healthcare is to determine how to apply AI in a way that promotes innovation, is transparent, and aligns with the public interest. Additionally, it is

investigating how to handle ethical issues pertaining to data privacy, employment automation, and prejudice amplification.

AI integration in healthcare has great potential to enhance clinical laboratory testing, treatment selection, and disease detection. AI technologies can outperform humans in a number of healthcare domains by utilizing vast datasets and spotting trends. AI minimizes human mistake while increasing accuracy, lowering expenses, and saving time. Personalized medicine, drug dosage optimization, population health management, guidelines, virtual health assistants, mental health care assistance, patient education, and patient-physician trust are all potential benefits. The primary focus of artificial intelligence (AI) in healthcare during the past 50 years has been disease , diagnosis and treatment. Although they had the ability to correctly identify and cure illnesses, early rule-based systems were not entirely approved for use in clinical settings. Additionally, their integration with clinical procedures and health record systems was subpar, and their diagnostic abilities were not appreciably superior to those of humans.

The application of AI in healthcare has enormous promise for enhancing patient outcomes, aiding precision treatment, enabling more precise diagnosis, and streamlining healthcare administration. But in order to properly utilize AI, interdisciplinary cooperation between AI specialists, medical practitioners, legislators, and patients is necessary to guarantee the ethical and responsible integration of AI technology into the healthcare system.

Difficulties of AI in healthcare

The actual application of AI-enabled solutions in clinical practice is currently somewhat restricted, despite the promising potential. In addition to privacy issues, AI technology has various methodological and technical drawbacks. The following are the main issues with AI in healthcare:

Inadequate Medical Information:

For the clinical and technical validation of AI models, clinicians need high-quality datasets. However, gathering patient data and photos to test AI algorithms becomes difficult because medical data is fragmented across multiple IT platforms. Another challenge is that interoperability issues may prevent medical data from one institution from being interoperable with other systems. The healthcare industry has to focus on methods for standardizing medical data in order to expand the quantity of data available for testing AI systems.

Performance Metrics That Are Clinically Irrelevant:

It's not always possible to apply the metrics used to evaluate an AI model's performance in healthcare contexts. The AI chasm is the difference between the technical accuracy of AI tests and the clinical efficacy shown in the actual world. Developers and physicians should work together to look at how AI algorithms improve patient care in order to close this gap. They can accomplish this by employing decision curve analysis to evaluate the correctness of AI models. By comparing the datasets and calculating the

likelihood that an AI model will succeed in the real world, this approach allows them to assess the clinical utility of a prediction model.

Methodological Research Flaws:

There are not enough established methodologies, prospective research, or peer-reviewed studies of AI in healthcare. The majority of studies have been retrospective and based on historical patient medical records. However, to realize the true value of AI diagnosis in real-world settings, physicians must study current patients over time, which means prospective research. And for reliable prospective research, doctors should monitor the health of their patients by combining physical examinations with telehealth visits and remote monitoring technologies (sensors and trackers). Notwithstanding the possible advantages, there are a number of obstacles to overcome before AI can be used in healthcare.

Since AI relies on digital data, its potential is limited by disparities in the quality and availability of data. Large and complicated data sets also take a lot of processing resources to analyze. Concerns have been raised over how comfortable doctors and patients are exchanging confidential health information digitally. Artificial intelligence (AI) systems may not be able to replicate human qualities like compassion.

Ethical and Social Issues, Safety and Reliability:

When AI is utilized in healthcare to operate machinery, provide therapy, or make judgments, reliability and safety are crucial concerns. AI is capable of making mistakes,

which could have major repercussions if they are hard to find or have repercussions. An AI app, for instance, was used in a clinical experiment conducted in 2015 to identify individuals who were most likely to experience problems after contracting pneumonia and, as a result, require hospitalization. Due to its incapacity to consider contextual information, this app incorrectly advised physicians to send asthmatic patients' home.

Transparency and Accountability:

Determining the underlying logic that produces AI's outputs can be challenging or impossible. While some AI is private and purposefully kept under wraps, others are just too complicated for the average person to comprehend. Because machine learning technologies constantly modify their own settings and rules as they learn, they can be very opaque. This makes it difficult to verify AI system outputs and spot biases or mistakes in the data.

Data Bias, Fairness and Equity:

While AI applications can potentially lessen human error and bias, they can also mirror and reinforce biases in the training data. There have been worries expressed over the possibility that AI could result in covert or noncompliant discrimination against constitutionally protected traits like age, gender, ethnicity, and disability.

Effects on Patients:

People may be empowered by AI health apps to assess their own symptoms and, when practical, take care of themselves. AI systems designed to assist those with impairments or chronic illnesses may improve people's quality of life, independence, and feeling of dignity. They may also allow those who might have otherwise needed care facility admission to remain in their homes for longer. However, if AI technologies take the role of staff or family interaction with patients, there have been worries expressed about a loss of human touch and a rise in social isolation.

Effects on Healthcare Professionals:

If AI challenges their knowledge, healthcare workers can feel that their independence and power are in jeopardy.The deployment of AI decision support systems may have an impact on healthcare practitioners' ethical duties to specific patients.

The advent of AI is probably going to alter the knowledge and abilities needed by healthcare workers, as is the case with many new technology. AI may make it possible in some fields to automate operations that were previously completed by humans.2. Health care providers may be able to spend more time interacting with patients directly as a result. There are worries, meanwhile, that the deployment of AI systems could be exploited as an excuse to hire less qualified workers.

Data Privacy and Security:

Many people would consider the data used by AI applications in healthcare to be private and sensitive. There are legal restrictions on these. However, information about the user's and people around them's health status may be gleaned from other types of data that are not directly related to health status, such as social media activity and internet search history.

Malicious Use of AI:

Although artificial intelligence (AI) has the potential to be beneficial, it might potentially be used maliciously. For instance, there are concerns that AI might be applied to secret screening or monitoring. Without the subject's knowledge, artificial intelligence (AI) systems that analyze mobility patterns identified by tracking smartphones and motor behavior—such as how a person types on a keyboard—could disclose details about their health.

AI might be used to launch cyberattacks more widely and at a lesser financial cost. As a result, there have been demands for governments, scientists, and engineers to consider AI's dual-use nature and get ready for any potentially harmful applications of the technology.

Regulatory Landscape in AI Driven Healthcare:

The abstract nature of AI concepts is currently the problem. To achieve the aforementioned concrete consequences, AI systems must become more transparent,

precise, and consistently correct. In order to manufacture products, medical device makers are required by the FDA to establish a quality system. Throughout its existence, this system should be committed to producing, distributing, and maintaining consistently high-quality products that operate in accordance with their specified requirements and applicable laws. This focus on quality must also guarantee that clinically deployed healthcare technology, such generative artificial intelligence, satisfies the required safety and efficacy standards.

Groups like the European Commission, ENISA, and DARPA develop ethical AI standards in addition to legal actions; these standards include supporting global harmonization, lowering reliance on third parties, and promoting cyber-hygiene. With an emphasis on ethics, quality, and clarity in healthcare, all of these activities help to influence the complicated world of AI legislation.

However, the constantly evolving tech landscape presents new difficulties that call for ongoing adaptations, particularly when it comes to ensuring seamless collaboration across various AI systems in healthcare. Collaboration across the industry is necessary to address this persistent issue and guarantee that diverse technologies can successfully reduce risk in real time.

Future of AI Healthcare:

Data inconsistencies, research shortcomings, and privacy protection issues prevent advanced AI models from being widely used just now, but these issues can be fixed. AI presents tremendous opportunities to improve drug research, early symptom

prediction, and diagnostics in healthcare. Furthermore, healthcare companies are already benefiting from the simplification of their workflow provided by existing AI and ML-based technologies (AI voice assistants). AI in healthcare therefore appears to have a bright future. Professionals who want to start a lucrative career in this industry should therefore keep up with the latest developments. Choose from Emeritus' extensive library of online healthcare courses covering the newest subjects in the sector as a starting point for this upskilling, and sign up for the appropriate program to further your career.

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CHAPTER 3

A CRITICAL INTERDISCIPLINARY PERSPECTIVE ON THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT AND FUNDAMENTAL RIGHTS

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ABSTRACT

The 2030 Agenda, approved by 193 member states of the United Nations, formulates 17 Sustainable Development Goals (SDGs) to promote economic, social and environmental sustainability. Although it proposes an ambitious global vision, its progress has been characterized by significant obstacles, particularly in Latin America and the Caribbean, where there are glaring disparities. This paper provides a comprehensive interdisciplinary analysis of the 2030 Agenda for Sustainable Development, with particular emphasis on its convergence with fundamental rights. This study analyzes the role of regional mechanisms, such as the Economic Commission for Latin America and the Caribbean (ECLAC), in facilitating the implementation of the Sustainable Development Goals (SDGs) and assesses the quadrennial progress report, emphasizing the obstacles exacerbated by the COVID-19 pandemic. From a fundamental rights perspective, there is concern about the agenda's insufficient focus on important issues such as environmental degradation, artificial intelligence and governance. The analysis indicates that, despite diplomatic efforts, the agenda's commitments remain largely voluntary, resulting in

insufficient progress. In conclusion, the report suggests that greater political commitment, mandatory compliance and greater stakeholder engagement are needed to close the gaps in achieving the Sustainable Development Goals by 2030.

I. INTRODUCTION (UNITED NATIONS, 2018)

The slow global economic growth, social inequalities and environmental degradation that are characteristic of our current reality present unprecedented challenges for the international community. Indeed, we are facing an epochal change: the option of continuing with the same patterns of production, energy and consumption is no longer viable, making it necessary to transform the dominant development paradigm into one that leads us down the path of sustainable, inclusive and long-term development.

This epochal change is necessary in the case of Latin America and the Caribbean, which is not the poorest region in the world, but the most unequal. Faced with these challenges, the 193 Member States of the United Nations, together with a large number of actors from civil society, academia and the private sector, engaged in an open, democratic and participatory negotiation process, which resulted in the proclamation of the 2030 Agenda for Sustainable Development, with its Sustainable Development Goals, in September 2015.The 2030 Agenda for Sustainable Development, which includes 17 Goals and 169 targets, presents an ambitious vision of sustainable development and integrates its economic, social and environmental dimensions. This new Agenda is the expression of the wishes, aspirations and priorities of the international community for the next 15 years.

It is a universal commitment made by both developed and developing countries, within the framework of a strengthened global partnership, which takes into account the means of implementation to achieve change and disaster prevention due to extreme natural events, as well as mitigation and adaptation to climate change.

During that session, resolution 700 (XXXVI) was also adopted, creating the Forum of Latin American and Caribbean Countries on Sustainable Development as a regional mechanism for the follow-up and review of the implementation of the 2030 Agenda for Sustainable Development, including the Sustainable Development Goals and their targets, as well as their means of implementation, and the Addis Ababa Action Agenda.

The methodology used was the analysis of the results of the reports issued by the United Nations. Both generic and disaggregated reports.

II. ECLAC 'S PRIORITIES TO SUPPORT THE IMPLEMENTATION AND FOLLOW-UP OF THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT IN LATIN AMERICAN AND CARIBBEAN COUNTRIES. (UNITED NATIONS, 2018)

1. Strengthen the regional institutional architecture.

2. Strengthen the analysis of the means of implementation of the 2030 Agenda at the regional level.

3. Support the integration of the SDGs into national development plans and budgets.

4. Promote the integration of the measurement processes necessary for the production of SDG indicators in National and Regional Statistical Development Strategies, as well as

the consolidation of national statistical systems (NSS) and the leading role of national statistical offices (NSOs).

III. QUINTESSENCE OF THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT.

The 2030 Agenda for Sustainable Development, approved in September 2015 by the United Nations General Assembly, establishes a transformative vision towards economic, social and environmental sustainability for the 193 Member States that subscribed to it and will be the reference guide for the institution's work in pursuit of this vision over the next 15 years. This new roadmap represents a historic opportunity for Latin America and the Caribbean, as it includes high-priority issues for the region, such as the eradication of extreme poverty, the reduction of inequality in all its dimensions, inclusive economic growth with decent work for all, sustainable cities and climate change, among others.

The 2030 Agenda is a civilizational agenda, which puts people's dignity and equality at its core. Being ambitious and visionary, it requires the participation of all sectors of society and the State for its implementation. Therefore, representatives of governments, civil society, academia and the private sector are invited to embrace this ambitious agenda, discuss it and use it as a tool for the creation of inclusive and just societies, serving the people of today and future generations. (UNITED NATIONS, 2018). Incidentally, we will refer to the 17 objectives later in this report when we analyze progress on them.

IV. ANALYSIS OF THE PROGRESS OF THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT. EIGHT YEARS LATER AND SIX YEARS FROM THE DAY D AND HOUR H

4.1. Quadrennial progress report on the progress and regional challenges of the 2030 Agenda for Sustainable Development in Latin America and the Caribbean. (UNITED NATIONS, 2019)

It is difficult to recognize in the international political economy of 2019 the agenda of issues and negotiations that preoccupied the international community in 2015. Over the past four years, international relations have turned around on such a scale that it could be said that we are living in an entirely new world. There has been a qualitative change in the dynamics of the political economy. This change arises from imbalances that have been brewing for a long time, as noted in CEPAL (2016).

4.2. 2020 Sustainable Development Goals Report. (UNITED NATIONS, 2020)

In principle, the annual reports provide an overview of global implementation efforts to date, highlighting areas of progress and those where further action is needed.

Some of the main conclusions:

i) An estimated 71 million people are expected to fall back into extreme poverty by 2020, the first increase in global poverty since 1998. Loss of income, limited social protection and rising prices could put even previously safe people at risk of poverty and hunger.

ii) Underemployment and unemployment resulting from the crisis mean that approximately 1.6 billion workers already vulnerable in the informal economy (half of the

world & #39;s labor force) may be significantly affected, with an estimated 60% drop in income during the first month of the crisis.

iii) The more than 1 billion slum residents around the world are at serious risk from the effects of COVID-19, such as lack of adequate housing and running water in dwellings, shared toilets, poor or absent waste management systems, overcrowded public transportation, and limited access to formal sanitation facilities.

iv) Women and children are also among those most affected by the consequences of the pandemic. The disruption of certain health and vaccination services, as well as limited access to nutrition and food services, could result in hundreds of thousands of additional deaths among children under five and tens of thousands of additional maternal deaths by 2020. Reports of domestic violence against women and children have soared in many countries.

v) School closures have affected 90% of the world's students (1.57 billion) and caused more than 370 million children to skip school meals on which they depend. Given the lack of access to computers and the Internet at home, remote learning is out of reach for many. Some 70 countries reported moderate to severe disruptions or total suspension of childhood immunization services during March and April 2020.

vi) As more families fall into extreme poverty, children in poor and disadvantaged communities are at much greater risk of becoming involved in child labor, child marriage and child trafficking. In fact, global progress in reducing child labor is likely to be reversed for the first time in 20 years.

4.2.1. Sustainable Development Goals 2020 Report (qualitative results). (SUSTAINABLE DEVELOPMENT GOALS, 2020)

These Goals require immense political will and ambitious action by all stakeholders. However, as Member States recognized at the SDG Summit last September, global efforts to date have been insufficient to achieve the change we need, jeopardizing the Agenda's promise to current and future generations. Due to COVID-19, an unprecedented health, economic and social crisis threatens lives and livelihoods, making achievement of the Goals even more difficult. By early June, the death toll had exceeded 400,000 and continued to rise, affecting almost every country. Health systems in many countries have been on the verge of collapse. The livelihoods of half the world's workforce have been severely affected. More than 1.6 billion students are out of school and tens of millions of people are being pushed back into extreme poverty and hunger, wiping out the modest progress made in recent years.

4.2.2. Disaggregated results, objective by objective.

I) OBJECTIVE

1. End poverty in all its forms everywhere. (UNITED NATIONS, 2018)

Consequences of COVID-19.

COVID-19 causes the first increase in global poverty in decades: $23.6 billion in direct economic losses (from 63 countries in 2018). COVID-19 changes the forecast for the global goal of ending extreme poverty. In-work poverty is projected to rise sharply as a result of the pandemic.

Social protection coverage varies widely from region to region and many are left exposed during the current crisis. Disasters disproportionately affect the least developed countries.

II) OBJECTIVE

2. To end hunger, achieve food security and improved nutrition and promote sustainable agriculture. (UNITED NATIONS, 2018).

Consequences of COVID-19.

The pandemic is an additional threat to food systems. In 2019, 21.3% of children under 5 are stunted. In 2019, 6.9% of children under 5 are affected by wasting (47 million). Small-scale food producers are hard hit by the crisis, comprising between 40%-85% of all producers in developing regions. The recent increase in food insecurity is likely to worsen due to COVID-19. Small-scale food producers, already disadvantaged, are hard hit by the effects of the pandemic. Stunting and wasting in children, already too high, is likely to worsen due to the coronavirus pandemic. The incidence of overweight in young children is increasing, which is a warning sign for future health problems. Investment in agriculture, relative to its contribution to the economy, continues to decline. In 2019, food price increases were mainly concentrated in sub-Saharan Africa.

III) OBJECTIVE 3.- To ensure healthy living and promote wellness for all at all ages. (UNITED NATIONS, 2018)

Consequences of COVID-19

Disruptions in care could reverse decades of improvements. The pandemic has disrupted childhood immunization programs in about 70 countries. Communicable disease conditions and deaths will increase cancellations of services will cause a 100% increase in malaria deaths in sub-Saharan Africa. Less than half of the world's population is protected with essential health services (2017). COVID-19 could reverse years of progress in reducing maternal and child mortality unless urgent action is taken. The rate of unintended pregnancies could skyrocket if continuity of family planning supplies and services is not ensured. The COVID-19 crisis has disrupted global childhood immunization efforts, with potentially deadly consequences. Intensive care for people with noncommunicable diseases is even more valuable in the COVID-19 era. COVID-linked service disruptions could cause a spike in illness and deaths from other communicable diseases.

The world is not delivering on its promise of universal health coverage by 2030. Rising out-of-pocket health care costs are reaching unsustainable levels, pushing millions of people into extreme poverty. The pandemic highlights the shortage of medical personnel worldwide, as well as the heavy burden of nursing on women. The pandemic highlights the need for greater preparedness for public health emergencies.

IV) OBJECTIVE 4

Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. (UNITED NATIONS, 2018)

Consequences of COVID-19.

School closures left 90% of students out of school, reversing years of progress in education. In low-income countries, the school completion rate for children is 79% of the richest 20% of households and 34% of the poorest 20% of households. School closures have left 90% of students out of school, reversing years of progress in education. Distance learning remains out of reach for at least 500 million students. Only 65% of primary schools have basic hand-washing facilities that are essential for the prevention of COVID-19.

School closures around the world can reverse years of progress in access to education. Without corrective measures, the effects of COVID-19 will only add to the obstacles poor children already face in completing their education. Distance learning remains out of reach for most students in the poorest countries. School closures create additional health and safety risks for vulnerable children. Lack of basic infrastructure in schools, such as hand-washing facilities, will hinder recovery from COVID-19.

V) OBJECTIVE 5

Achieving gender equality and empowering all women and girls. (UNITED NATIONS, 2018)

Consequences of COVID-19

Confinement increases the risk of violence (physical, sexual, psychological) against women and girls. Cases of domestic violence have increased by 30% in some countries. Women must be equally represented in leadership positions linked to the pandemic (Result: 25% in national parliaments, 2020 and 36% in local governments). Women are at the forefront in the fight against the coronavirus (they represent 70% of health and social workers). Women have greater burdens at home during the pandemic (they spend three times more hours than men in unpaid domestic and care work). COVID-19 exacerbates the risk of violence against women and girls. The global pandemic could set back progress made in ending child marriage and female genital mutilation.

Women spend more time than men in unpaid work, a burden that is likely to become heavier during the pandemic. Women are increasingly assuming positions of power, but the world is still far from parity. Women's lack of decision-making power extends even to their own reproductive health.

VI) OBJECTIVE 6

Ensure availability and sustainable management of water and sanitation for all (UNITED NATIONS, 2018)

Consequences of COVID-19

Three billion people worldwide lack basic hand-washing facilities at home (the most effective method of COVID-19 prevention). Water scarcity could displace some 700 million people by 2030. Some countries showed a 61% shortfall in meeting water and sanitation targets. Closing the water, sanitation and hygiene gaps is critical to contain the spread of COVID-19 and other diseases. Transboundary water cooperation needs to be accelerated. Alarming levels of water stress in many regions threaten the progress of sustainable development. Lack of freshwater in the poorest countries increases their vulnerability to climate change and water scarcity. The funding available for Goal 6 targets is insufficient to meet countries' needs. A global framework for water resources management has a poor implementation record.

VII) OBJECTIVE 7

Ensuring access to affordable, reliable, sustainable and modern energy for everyone.

COVID-19 implications

Affordable, reliable power is essential in healthcare facilities. One in four lacks electricity (2018). The rate of improvement in energy efficiency is less than the 3% needed (2017). financial flows to developing countries in support of renewable energy have increased to $21.4 billion in 2017. But, only 12% goes to LDCs. Electricity deficits are increasingly concentrated in sub-Saharan Africa. Slow progress on clean cooking solutions puts the health of nearly 3 billion people at risk. Renewable energy efforts need to be scaled up to achieve long-term climate goals.

Improvements in energy efficiency - key to reducing greenhouse gas emissions - fall short of the SDG target. The increase in international financing for renewable energy is encouraging, but only a fraction reaches the poorest countries.

VIII) OBJECTIVE 8

Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. (UNITED NATIONS, 2018).

Consequences of COVID-19

The world faces the worst economic crisis since the Great Depression (GDP per capita is expected to fall by 4.2% in 2020). During the pandemic, 1.6 billion workers in the informal economy are at risk of losing their jobs. Tourism faces unprecedented challenges. international tourist arrivals scenarios with COVID- 19. From 850 million to 1140 million (2020). COVID-19 may result in the loss of 400 million jobs in the second quarter of 2020. Even before the pandemic, economic growth in the least developed countries, although rapid, did not approach the 7% target. The steady increase in global labor productivity may falter in the face of the coronavirus crisis. The pandemic will have a particularly adverse effect on workers in the informal economy. Global unemployment may reach an all-time high in 2020, depending on the policies adopted. Occupational safety and health becomes an even greater challenge as workplaces reopen. Tourism faces unprecedented challenges, and many small island developing states face harsh new economic realities.

IX) OBJECTIVE 9

Building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation. (UNITED NATIONS, 2018).

Consequences of COVID-19

The aviation industry has suffered the deepest decline in its history. Passenger numbers declined by 51% from January to May 2020 (compared to the same period in 2019). Less than 1 in 5 people use the internet in LDCs (2019). The aviation industry, a driver of economic development, has suffered probably the steepest decline in its history. As a result of the pandemic, the already sluggish growth of the manufacturing industry has plummeted. Small-scale industries urgently need better access to financial services in order to resuscitate the global economy. Despite progress in recent years, investment in research and development must be accelerated, in part to address COVID-19. Mobile connections are virtually universal, but about half of the world's population is not connected, especially in LDCs.

X) OBJECTIVE 10

Reducing inequality within and among countries. (UNITED NATIONS, 2018).

Consequences of COVID-19.

The most vulnerable groups are most affected by the pandemic (the elderly, people with disabilities, children, migrant women, and refugees). The global recession could compress development assistance to developing countries in current development resources (from $420 billion in 2017 to $271 billion in 2018).

Fifty-four percent of countries with data have a comprehensive set of migration regulations. While the real incomes of the poorest in countries are rising, the rich continue to prosper disproportionately. Women with disabilities face various forms of discrimination, which intersect with each other. Workers receive a smaller share of the output they helped produce. Income inequality is declining in some countries, but levels remain generally high. The global recession could restrict donor aid to developing countries. Most regions have a long way to go to establish adequate migration policies.

XI) OBJECTIVE 11

Making cities and human settlements inclusive, safe, resilient and sustainable. (UNITED NATIONS, 2018).

Consequences of COVID-19

More than 90% of COVID-19 cases are in urban areas. Polluted air caused 4.2 million premature deaths in 2016. 47% of the population lives within 400 meters of public open spaces. The global progress made in decreasing the proportion of slum dwellers has been reversed and the pandemic increases their vulnerability. More public transport is needed in the world's cities. Beyond the devastation, the pandemic has prompted a positive rethinking of our cities. Open public spaces in the world's cities promote health and productivity, but access is often limited. Clear skies over some of the world's most polluted cities offer a taste of what could be.

XII) OBJECTIVE 12

Ensuring sustainable consumption and production patterns. (UNITED NATIONS, 2018).

Consequences of COVID-19.

The world continues to use natural resources unsustainably (2010- 2017). The pandemic is an opportunity to create recovery plans towards a more sustainable future. Between 2017 and 2019, 79 countries and the european union reported at least one policy to promote sustainable consumption and production. E-waste increased by 38%. but, less than 20% is recycled (2010-2019). Fossil fuel subsidies are contributing to the climate crisis (from $318 billion in 2015, to $427 billion in 2018). 13% of food is lost in the supply chain in 2016, (that is: in harvesting, transportation, storage, processing).

The world continues to use natural resources unsustainably. The increase in e-waste generation far outpaces its recycling rate. A significant portion of food is lost along the supply chain before it reaches the consumer. Despite the growing urgency of the climate crisis, governments continue to subsidize the fossil fuel industry. Countries must implement the principles of sustainable economic growth immediately. Companies must address the shortcomings in the quality of sustainability reporting.

XIII) OBJECTIVE 13

Adopt urgent measures to combat climate change and its effects. (UNITED NATIONS, 2018).

Implications of COVID-19

Only 85 countries have national disaster reduction strategies aligned with the Sendai framework. Climate finance continues to be higher than climate action in 2016 ($781 billion, for fossil fuels and $681 billion for global climate finance). Climate change continues to exacerbate the frequency and severity of natural disasters in 2018 (massive wildfires, droughts, hurricanes, floods, affected over 39 million people). The world is a long way from meeting the Paris Agreement target, indicating that catastrophic changes are on the horizon. Funding for climate action has increased significantly, but continues to be outpaced by investments in fossil fuels. Most developing countries have begun to formulate plans to strengthen resilience and adaptation to climate change. Despite its obvious importance, progress toward meeting the 2020 disaster risk reduction target has been slow.

XIV) OBJECTIVE 14

Conserve and sustainably use the oceans, seas and marine resources for sustainable development. (UNITED NATIONS, 2018).

Consequences of COVID-19

The drastic decrease in human activity triggered by COVID-19 could result in the oceans recovering. Global key global area of marine biodiversity covered by protected areas increased: 30.5% (2000), 44.8% (2015), 46.0% (2019). Ninety-seven countries signed the Agreement on Port State Measures, the first binding international agreement on illegal and unregulated fishing. Continued ocean acidification threatens the marine environment and derived ecosystem services.

Although protection of the marine environment is expanding, it is critical that coverage extends to key biodiversity areas. Countries are restricting illegal fishing through a binding international agreement, but even more concerted action is needed. Sustainable fisheries are vital to the livelihoods of communities in the most disadvantaged countries. Artisanal fishermen, major contributors to the economies of developing countries, continue to be marginalized. A pause in the attack on the world's fish stocks may not be enough to prevent the collapse of some fishing grounds.

XV) OBJECTIVE 15

Protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss. (UNITED NATIONS, 2018).

Consequences of COVID-19

Wildlife trafficking affects ecosystems and contributes to the transmission of infectious diseases. Forest areas continue to decrease at an alarming rate, mainly due to agricultural expansion. Ten million hectares of forest are destroyed each year (2015-2020). Two billion hectares of land area are degraded, affecting 3.2 billion people, leading to species extinction and intensifying climate change. Only one third of 113 countries are on track to meet their national targets for integrating biodiversity into national planning. Wildlife crime endangers both animal species and human health, including through new deadly diseases.

Land degradation affects billions of people, leads to species extinctions and intensifies climate change. Despite some progress, the world is failing to meet 2020 targets to halt biodiversity loss. Forest loss remains high despite increasing efforts to manage forests sustainably. Biodiversity is declining at an alarming rate. Less than half of key biodiversity areas are under protection, while progress has slowed considerably. Only one-third of countries are on track to meet their national biodiversity targets.

XVI) OBJECTIVE 16

Promote peaceful and inclusive societies for sustainable development, facilitate access to justice for all and build effective, accountable and inclusive institutions at all levels. (UNITED NATIONS, 2018).

Consequences of COVID-19

They further threaten global peace and security (in 2019, the number of people fleeing war, persecution and conflict exceeded 79.5 million, the highest level on record). The global intentional homicide rate slowly declined (from 5.9 per 100,000 Inhabitants in 2015, to 5.8 per 100,000 Inhabitants in 2018). Which translates to 440,000 homicide victims worldwide, One hundred and twenty-seven countries have passed right to information or freedom of information laws. Sixty percent of countries have overcrowded prisons, risking the spread of COVID-19. Every day, 100 civilians - including women and children - are killed in armed conflict despite the protections of international law. Efforts must be redoubled to reduce the global homicide rate, which is declining too slowly. Children are regularly exposed to various forms of violence, many of which go

unrecognized and unreported. Exposure to COVID-19 is one of many inhumane conditions faced by those incarcerated, often without sentencing. Human rights defenders, journalists and trade unionists are too often the targets of violent attacks. More countries now have freedom of information laws, but their implementation could be improved.

XVII) OBJECTIVE 17

Strengthening the means of implementation and revitalizing the global partnership for sustainable development. (UNITED NATIONS, 2018).

Consequences of COVID-19

Remittances to low- and middle-income countries-an economic lifeline for many poor households-are expected to decline (from $554 billion in 2019, to $445 billion in 2020). Foreign direct investment expects a decline of up to 40% in 2020. International funding for data and statistics was $690 million in 2017 (only 50% of the level it should be). Major donors say they will strive to protect ODA budgets, even as the coronavirus disrupts the global economy. After reaching a new peak, remittances are expected to decline sharply in 2020. Foreign direct investment and global value chains are likely to be affected by the coronavirus crisis. Global trade is expected to plummet as LDCs struggle to increase their share of exports. The Internet is now essential for many daily activities, but half of the world's population is still not connected. The need for reliable data continues to grow, but the poorest countries lack the resources to generate it.

V. INSULITOUS. ASPECTS NOT CONSIDERED AS AGENDA 2030 ITEMS.

i) Mining pollution.

ii) Smart cities.

iii) Transfer of environmental matters to judicial headquarters.

iv) New environmental principles.

v) Artificial intelligence. Due to the urgency of addressing the urgent need to use artificial intelligence, it deserves to be used in a cross-cutting manner to the other proposed points. Then, a comprehensive effect will be achieved, which in turn can contribute to safeguard the fundamental rights of people in this matter.

vi) Codification.

vii) Governance.

viii) Improved right to a healthy and wholesome environment.

ix) Inclusion of additional and new fundamental rights.

x) Training and awareness-raising.

xi) Environmental displaced persons.

xii) Environmental justice. Its importance and urgency lies in the urgent need to take environmental conflicts to the courts. This, in view of the fact that in the absence of environmental courts, they are only dealt with at the administrative level. Therefore, with an environmental judicial justice system, fundamental environmental rights are duly safeguarded.

xiii) Interdisciplinarity.

xiv) Interinstitutionality.

xv) Contaminating waste.

xvi) Loss of forests in the Amazon.

xvii) Artisanal mining.

xviii) Marine conservation.

VI. A FUNDAMENTAL RIGHTS PERSPECTIVE.

The equivocal and inert actions of the 2030 Agenda are clearly violating the fundamental rights of the population:

i) to peace and tranquility,

ii) to life,

iii) to the free development of the personality,

iv) to free development,

v) to a healthy environment, v) to a healthy environment,

vi) to the well-being and security of future generations, among others.

VIII. CONCLUSIONS

The points of the 2030 Agenda are not correctly selected. There was no prior situational diagnosis for their determination, nor order of priority. The existence of a majority of academic, professional, specialization and execution orphans, and a lack of knowledge and commitment to the corresponding topic on the part of the leading actors, can be deduced. The results of the progress of the Sustainable Development Goals of the 2030 Agenda are a resounding failure. The implementation of the 2030 Agenda is very

difficult to achieve by 2030, if not impossible. It is unacceptable that the analysis of the 17 points of the agenda should have been analyzed (as a failed justification) only from the perspective of the serious effects of the Coronavirus. We are more than halfway (2024), 9 years have passed and there is no convincing, majority progress. The members of the 2030 Agenda only have to get down to work in an intense and committed manner, because in 2030, they will not be able to justify themselves again with the well- known excuse of Covid 19.

Clearly, the evaluation of the disaggregated results, objective by objective, becomes disapproving. In addition to the lack of political will of the member countries of the 2030 Agenda, it is very distressing to learn that the verb governing the commitments of the Agenda is not: “is obliged or committed”, but rather: “is invited”. Consequently, it becomes impossible to apply the pacta sunt servanda principle, that is, to enforce what has been agreed or agreed. Hence the resounding failure of the 2030 Agenda. Diplomacy has been actively and assertively participating in the development of different spaces for exchange, networking and learning on the localization of the Sustainable Development Goals.

IX. SUGGESTIONS

Determine and implement the correct Sustainable Development Goals of the 2030 Agenda (this date could be extended), observing the considerations proposed, substantiated and developed in this work. Establish that the agenda items are mandatory. Then, it will be possible to achieve a greater commitment and political will to establish

mandatory compliance with the 2030 Agenda. Training and awareness-raising for Agenda 2030 stakeholders on issues of public management and fundamental rights.

X. GLOSSARY OF TERMS.

10.1. Agenda items. Refers to the topics or issues to be discussed at a meeting, conference or event. They are the specific topics that will be addressed and time will be devoted to their discussion and possible resolution.

Agenda items are the guide that determines the content and structure of a study or project, ensuring that the most important and urgent issues are addressed and that maximum use is made of time.

10.2. Previous situational diagnosis. This refers to a deep and exhaustive analysis of the current situation of a project, company, organization or any other specific context. It is like an x-ray that allows to understand the current reality, identify strengths and weaknesses, opportunities and threats, and thus be able to make better strategic decisions. The previous situational diagnosis is a fundamental tool for making strategic decisions based on real and updated information. It allows identifying opportunities and threats, analyzing strengths and weaknesses, and establishing a clear vision of the way forward.

10.3. Sustainable development. It is a concept that seeks to meet the needs of the present generation without compromising the ability of future generations to meet their

own needs. It is based on three fundamental pillars: i) Economic pillar: Seeks economic growth that is inclusive, equitable and generates quality employment, ii) Social pillar: Promotes equity, social justice, poverty reduction and access to education, health and housing, iii) Environmental pillar: Prioritizes biodiversity conservation, sustainable management of natural resources, pollution reduction and climate change. Sustainable development is a complex concept that requires the collaboration of governments, companies, organizations and citizens to achieve a more just and sustainable future for all.

10.4. Fundamental rights. They are a set of freedoms and guarantees inhere nt to the human person, which are essential for a dignified life and must be respected by all, including the State. These rights are: i) Universal: They apply to all persons, without distinction of race, sex, religion, nationality, ethnic origin, political opinion or any other condition, ii) Inalienable: They cannot be lost or renounced, since they are an intrinsic part of human dignity, iii) Indivisible: They are interdependent and must be considered as a whole, since the violation of one may affect the others. Fundamental rights are based on the recognition of human dignity and individual autonomy, and seek to protect people from the arbitrariness of power and discrimination. Fundamental rights are recognized in various international instruments, such as the Universal

Declaration of Human Rights, the American Convention on Human Rights and the International Covenant on Civil and Political Rights. They are also enshrined in the constitutions of many countries, including the Spanish Constitution. The protection of

fundamental rights is fundamental to the development of a democratic and just society. It is the responsibility of everyone, including the State, companies and individuals, to ensure respect for and protection of these rights.

10.5. Interdisciplinary. It refers to an approach that integrates knowledge, methods and perspectives from different disciplines and sciences of human knowledge to address a specific problem or issue. Instead of treating each discipline in isolation, the interdisciplinary perspective seeks collaboration and interaction among them to obtain a more complete and holistic understanding of the object of study, the interdisciplinary perspective is an approach that seeks collaboration and integration of different disciplines and sciences to obtain a more complete understanding and more effective solutions to real-world problems.

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CHAPTER 4

OPPORTUNITIES AND THREATS OF THE USE OF ARTIFICIAL INTELLIGENCE IN PRESCHOOL EDUCATION

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ABSTRACT

The development of modern technology requires learning about the ways and variants in its application. Each implemented news must be supported by knowledge and reflection on what the consequences of their application may be, as well as knowledge of its advantages, as well as whether there are risks associated with its implementation. The article is a summary of the current knowledge in the use of AI at the lowest level of education in the field of methodology and management of institutions using it. The low level of current application does not currently allow for research on the application of artificial intelligence in preschool education. However, it is necessary to create cognitive capabilities for this issue and prepare for the implementation of probable scenarios. Predicting what role artificial intelligence will play in education depends on a carefully conducted reconnaissance in the available literature and practice. The aim of the article is to analyze the available sources on the use of AI in education and to verify at the level of reflection what educational and organizational advantages it brings in the field of preschool education.

Key words: *Artificial intelligence, preschool education, opportunities and threats of AI implementation in preschool education.*

1. Introduction

The era of implementing artificial intelligence in almost all areas of economic and social life began. Each generation experiences changes that modern technologies serve. Education is also transforming, which is visible in technological trends and orientations of education. Continuous reform of educational systems, almost all over the world, aims to achieve the goals of striving to prepare children and young people for life in the modern world in the best possible way. The combination of goals and the latest trends seems to be an apt pursuit.

The main aim of the article is to analyse whether the key element of our modernity will play a role in modern education, especially at the kindergarten level. It has already been clearly stated that a revolution in the processes of learning, teaching and education should be expected. Probably the use of AI with unexpected dynamics will dictate quick but also ambiguous answers from educational practices. Artificial intelligence and the ways in which it is applied will bring innovations in the methods and forms of education used so far. On the other hand, questions and reflections arise regarding the form and quality of interpersonal relations, without which the educational system will not fulfill its educational and caring role. Therefore, before implementing AI, it is necessary to deeply consider the ways, opportunities and risks of using it in preschool education.

Artificial intelligence is a product of computer science and electronics, it is a derivative of mathematical algorithms, networks of artificial neurons, heuristics, logic and expert systems, which, when introduced into an integrated complex contribution, produce thought processes. The epochal event fills us with fear of the consequences of using a machine devoid of empathy, thinking like a human. These are, of course, the fears of a man who does not know what to expect from another human being. The consequences of the use of artificial intelligence in educational impact should therefore be analysed and planned in detail now.

A brief history of artificial intelligence is brought closer by the fact that it was predicted as early as the 17th century by Descartes' prediction that in the future machines would take over thinking and initiative for humans. Such an image was brought to reality

only in 1959, when John McCarthy used the term artificial intelligence at a scientific conference to describe the field of science involved in the construction of intelligent machines (Utracki, 2021). The first decades of the artificial intelligence era brought experiments and various other studies on chatbots, chatterbots, linguabots, natural language generating that would allow you to ask questions and generate answers. The culmination of the activities was the creation of a machine that directly translated from French into English. Since 1988, there has been a clear acceleration in achievements in this field, when the period of machine learning technology began (Miernik, 2023). Further dynamic development of work on the technology of the future has been crowned in the use of AI in many fields. It should be mentioned that it is used in many areas:

- recognition of creditworthiness, profiles of bank customers, i.e. more and more widespread use in economics
- identification of persons, speech identification, handwriting identification, identification of objects, faces;
- systems that enable machine translation of texts;
- research on specific fields of science, life on a specific area of the Earth, a specific community;
- use in artistic creation – composing musical pieces, writing novels, writing poetic products;
- expert systems used in machines, consisting in the possibility of obtaining answers to every question in natural language;
- the use of fuzzy logic systems in technological processes controlled in the absence of all data (Kasperski, 2003).

Artificial intelligence has currently taken over many fields of science and economic and social life. It is used in agriculture, health care, administration, and even in relationships between people. The question should be asked where this revolution is heading, what is the goal of the creators of modern programs. In addition to security and problem-solving assistance, exploration in the field of military operations can be used

against humanity. It can become, if it is not already used for the purpose of monitoring and spying on every person. On the one hand, it is one of man's greatest achievements, and on the other hand, there are fears that it will replace man in so many places that whole masses of people will exist on the brink of poverty due to lack of work (Biedroński, 2022). Oxford research reports that almost half of professions are at risk of being automated, and about 7% of professions will disappear from the social space (OECD).

The trend of automating life raises concerns about human relationships, which are at a unique point of impact of the automation of social life. Man is a creature created to create and shape himself in social relations, to function thanks to them. Lack of them in contacts occurring during social functioning disturbs mental health, emotional well-being, causes loneliness, a sense of isolation, stress, and anxiety.

The idea behind the improvement of AI is to create intelligence that develops in the same way as humans. The application is the goal of participation in social life in a way that is on par with human intelligence (Baran et al., 2022). However, artificial intelligence is not able to act on its own, it needs people who will provide it with information. The goal and action plans require human implementation and constant diversification of new information, they must be constantly stimulated and subjected to specific algorithms.

Objective

The article presents a study on the application of artificial intelligence (AI) in preschool education. It analyzes how AI transforms the educational process. He draws attention to the issues raised by the integration of AI with preschool education.

Research Method

An integrated research approach was used, combining a method of descriptive, comparative, and descriptive analysis to provide an in-depth and multifaceted understanding of the role and potential of AI in preschool education. Inductive reasoning was used in the considerations, which allows general conclusions to be drawn from the observed data.

1.1 Definitions

Artificial intelligence is a phenomenon that is already known to everyone, and on the other hand, there is still a belief that everything is yet to begin. From one perspective, it is a violent phenomenon, surprising the world with its exceptional uniqueness and unpredictability, and on the other hand, it is even a necessity in the industrial and then digital revolution that began years ago (King, 2017). The growing interest in the inventions of the latest technologies has already led to the need to use them in strategic planning of the development of cities, countries and regions. After all, it is a technology qualified as fundamentally changing life in every area of it. Until now, the Internet was an invention of such magnitude, and before that the steam engine. Such a qualification is said to be when it radically changes a person's life and work. Feliks Kurp states that it is currently difficult to define artificial intelligence, because depending on the field, different definitions are given, delineating different meanings.

- They have the ability to acquire knowledge and learn;
- They are autonomous in dealing with new situations without outside help;
- They have the ability to adapt to new environmental conditions (Kurp, 2023).

The task of the kindergarten is to support the multidirectional activity of the child by organizing conditions for the development of the child's experiences in the area of physical, cognitive, emotional and social development. Preschool education is a stage of education aimed at supporting the development of a child aged 3 to 7 to enable the child to be ready to start school education at its first, elementary level. This is achieved by organizing the process of care, teaching and upbringing (Klim-Klimaszewska, 2010). Detailed provisions of the school education law set out the rules and objectives of the teacher's conduct to help the child become ready for school. The teacher organizes conditions that provide the child with multidirectional activity, while providing opportunities for free play and rest in an atmosphere of self-esteem and ensuring the child's individual needs. The content of these guidelines is extended to include the formation of habits

related to independence, care for health, mobility, understanding one's own and other people's emotions. The Regulation also mentions the organisation of educational and task-related situations in which the child encounters the need to meet mental and cognitive needs at the child's level, stimulating the child's emotional and aesthetic sensitivity, with reference to all manifestations of the life of society, its culture (speech, behaviour, music, clothing, art, dance, singing, environment) and ways of communication (Journal of Laws of 2017, item 356, as amended). Preschool education also includes learning and assimilating social norms, rules of living in the natural environment, and awakening interest in the world. The multifaceted nature of preschool education should also be supported by the fact that it is a source of values, the foundations of the child's identity. The guideline for proceeding is the core curriculum, which is a list of skills and knowledge that a child acquires in kindergarten in order to reach school maturity. To sum up, the tasks of preschool education include the areas of physical activity, body and health, personal development, socio-emotional aspects, communication, language, cultural aspects, aspects of mathematical, natural and technical knowledge (Karbowniczek, 2011). This requires integrated activities of pedagogical staff in cooperation with parents and social institutions.

When talking about preschool education, it is also necessary to cite the humanistic paradigm, which gives the child a central position in the educational process. The most important are their needs, individual abilities, creativity, activity in self-definition and self-creation. Humanistic theories emphasize the important role of the human will, which creates its identity and has independent thinking. Psychology, which is the foundation of such an approach, emphasizes the uniqueness of the child and his subjectivity. It should be understood that he is a person who can influence other people and the community, has his own ideas and aspirations (Kwaśniewska, 2018).

The perception of the approach to the child in preschool education makes it necessary to use appropriate methods. These are ways of educational work, which is based on methods that trigger creative invention. Active, creative methods, based on searching, learning through action (Moroz, 2016). Among the forms of child's activity, education focuses on the child's play, which is an area of self-fulfillment for the child, with

simultaneous active involvement. The child, without embarrassment, has time for spontaneous play, in which he learns and searches (Waloszek, 2009).

2. Methodology

An integrated research approach was used, combining the methods of descriptive, comparative and descriptive analysis. This will allow for a multifaceted understanding of the role and potential of artificial intelligence in preschool education. Inductive reasoning was used in the considerations, which allows general conclusions to be drawn from the observed data. The aim of the research is to assess the opportunities and threats of the educational process at the preschool level from the use of artificial intelligence.

Thanks to the use of the descriptive analysis method, the current use of artificial intelligence and their trends in the context of preschool education will be described. The comparative analysis method will facilitate the assessment of the use of AI in methods used in preschool education. Descriptive analysis will be used to study the use of AI in specific cases in preschool education and usefulness.

3. Using artificial intelligence in preschool education

Over the past few years, artificial intelligence has ceased to be a mysterious phenomenon. It is also known in education. It supports the teacher in creating teaching aids and helps in individualizing teaching. The question arises whether it can be used at the lowest level of education, which is pre-school education.

The popular chat GPT, where you can use your voice, involves asking questions in the language you use every day and getting answers. This is information that the AI has obtained by entering specific data, information, texts. This is a tool known as dialogic (or generative) AI. This tool can have many applications in preschool education. It allows for individualization by automatically adapting to the level of the question asked. The specificity of the question depends on the intellectual level of the child, so the tool can be used by a child with special educational needs. The use of the tool does not mean replacing the teacher. The teacher should be understood as a partner who supports the child in the search for information.

This chat can be successfully used in the work of a teacher preparing an outline for conducting classes. Stories on a specific topic, poems, auditory, grammar and dictionary exercises can be generated. Previously prepared texts can be improved to adapt to a given age group of preschoolers. The quality of the use of dialoguing AI depends on the teacher's digital competences (Jankowska, 2023). The use of AI-based systems enables a personalized approach to the student's graphic skills. It can be helpful in assessing its strengths and the need for an individual approach to the skills that still need to be shaped. Currently operating artificial intelligence systems can also be helpful in working with a student with special educational needs, as it has the ability to record and analyze the child's progress. The teacher then obtains a picture of the student's achievements and receives help in diagnosing the areas that should be treated. AI tools should be used in speech therapy. They will make it easier for the speech therapist to work and adjust individual plans of work with a child with speech disorders. For a child, they can certainly be an attractive tool to support the therapy process.

It is an obvious fact that educating a child in the virtual world can be a systematically recurring incident. You can't leave a child in task-oriented situations, but by all means, an AI tool should be used in the education of the youngest. Nothing can replace a teacher, who is above all a guardian and a model of activity in various areas. The AI tool is able to analyze the child's behavior, determining their level of involvement, possible emotional problems, and determining indicators of well-being. It is therefore an aid in the observations made by the educator and the teacher. It is very important to detect changes in the child's behavior early in order to react with psychological support in time. In addition to the above-mentioned aspects, the AI tool can generate an individual timetable for a specific child, taking into account their needs and preferences. Such monitoring and analysis of emotional reactions will help to adjust the child's involvement in the proposed material, area of knowledge.

AI-based tools include educational platforms. They are associated with remote learning, which certainly does not play a role in the education of the youngest. However,

in some respects, it can also be used in preschool education. One of the youngest trends in the use of platforms is gamification. The proposed learning and acquisition of skills and knowledge takes place on the basis of a game and competition. A little student can earn badges, points, symbolic and valuable "coins" (https://edu-platformy.com/platforma-edukacyjna).

Natural language processing tools can be helpful for a child who is intuitively learning about the world of grammar. These must be voice-based tools due to the fact that only the first experiences in the world of child's handwriting are formed. They can also be tools supporting the learning of foreign languages, especially English, which is introduced in the core curriculum of preschool education. To help diagnose a child's reading level, tools based on Alex and Siri are currently being developed, which will be a key aid in shaping the skills of young students. Among the voice-based tools, there are also systems that allow the use of voice commands. They can be successfully used in the education of children with disabilities who will never learn the written language.

To sum up, the inclusion of artificial intelligence in the activities of kindergartens is indispensable in the near future. Modern technology is starting to play an increasingly important role, and the advantages of using it in preschool education include:

- Individualization of the educational process depending on the needs, level and pace of the child's development;
- Personalized classes in terms of the child's individual interests and skills, which increases the child's involvement in learning and increases the effectiveness of the process;
- Help in work for the teacher;
- Enabling early detection of educational needs and necessary intervention and establishing a support plan for the child;
- Enabling the initiation of the child's creativity with the use of musical, artistic and artistic applications;
- Shaping cognitive abilities related to logical thinking;

- Providing immediate feedback on the exercise, the work done by the child and correcting mistakes;
- Facilitate the monitoring of the child's progress and modify educational programs;
- Support for social development through the use of role-play games that facilitate empathy, cooperation, communication;
- Diversifying the teaching material with interactive activities, games, stories with work on visual tools;
- Modifications in the way the preschool facility is managed.

It is impossible not to mention that education with the use of the latest technologies is necessary due to the fact that the child is acquiring the basics of technical knowledge in an automated world. Adaptation to the changing world must take place already in kindergarten along with preparation for the hygiene of life with the media.

The aim of this study is to show the threats to preschool education in the perspective of the use of artificial intelligence. The most important, key aspect of education at the preschool level is the human factor. An educator, teacher, therapist is a person who has empathy, the ability to understand emotions and react to the child's emotions. Artificial intelligence has no way of understanding the child, it can only react with information about the need for intervention. The conversation and interaction created during contact with the machine should take place with the participation of an adult, not replace it.

The high frequency of use of AI tools leads to addiction to this way of learning. It would be appropriate to balance the appropriate variety of methods to balance the child's ability to move and to exclude the possibility of overstimulation by virtual images.

The threat posed by AI tools to a preschooler is that they are excluded from community life while performing tasks using AI. Peer group experiences are the most important aspect of development at this age. Cooperation, interacting, communicating and engaging in peer activities is a driving force for not only social, but also cognitive and emotional development. On the other hand, limiting social contacts may limit these

spheres of development. The human factor is also important in connection with the failure and success of the student. The machine cannot replace a smile, praise, or help build emotional resilience.

Artificial intelligence is a system of programs that has been fed with information by a human. Information transformed by AI and given to the student may turn out to be erroneous, outdated. Too much trust in the program may turn out to be a distorted image of reality. A student should have a dose of uncertainty and a habit of seeking knowledge from other sources. When thinking about a preschool child, it is difficult to create requirements for him or her in terms of prediction, suspicion of AI, and thus a critical approach.

AI software has the ability to collect data about the person using it. This is a threat to the sense of security of the teacher and the parents of a child working with AI. This can be sensitive data that many people have access to, which can raise concerns about the use of education. In parallel with investing in AI tools, you should invest in security systems.

Currently, the use of AI is associated with very high implementation costs. This is a big step for the education system to overcome, and therefore also announces the difficulties of implementation in kindergarten.

4. Applications

Artificial intelligence can be an attractive addition to the didactic base of any kindergarten. After reaching school maturity, the child will have more and more opportunities to use the latest technologies, so already at this stage they should adapt to work in the digital world. On the other hand, propaedeutic knowledge and the possibility of communing with AI must be dosed, carried out under the tutelage of the teacher. Proper media hygiene habits are the most important at the age of a preschooler. Also, developing the habit of using AI should be dosed to secure time and opportunities for spontaneous play of the child. The priority is the harmony of development and formation of personality and identity, which will not be provided by artificial intelligence. Responsibility for the child's development is a priority in preschool education.

Artificial intelligence will probably modify the education system to the extent of a revolution. The task of educators is to make the most of every opportunity to support the child's development, to shape their interactions at the highest possible level, but with the assumptions of the student's subjectivity.

Conclusion

Artificial intelligence will make significant changes in preschool education. It thus requires educational systems to quickly adapt to changing technologies and changes in current educational practices, which will have a significant impact on the future of teaching and innovation in preschool working methods. Artificial intelligence can be an attractive addition to the didactic base of any kindergarten.

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CHAPTER 5

ETHICAL AND GOVERNANCE CHALLENGES ADDRESSES THE ETHICAL IMPLICATIONS OF AI IN SDG

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ABSTRACT

As Artificial Intelligence (AI) becomes a transformative tool for achieving the United Nations' Sustainable Development Goals (SDGs), it simultaneously introduces significant ethical and governance challenges. This chapter explores the ethical implications of AI technologies deployed across diverse SDG applications, focusing on critical issues such as data privacy, algorithmic bias, and fairness. It highlights how the reliance on large datasets and machine learning models often leads to ethical dilemmas, such as breaches of individual privacy, perpetuation of systemic biases, and inequitable outcomes that disproportionately affect marginalized communities. Furthermore, the chapter examines governance challenges, including the lack of standardized ethical frameworks, the need for transparent accountability mechanisms, and the complexities of ensuring global cooperation in regulating AI. Through case studies and real-world examples, it underscores the importance of embedding ethical considerations throughout the AI lifecycle—from data collection and algorithm design to deployment and monitoring. The

chapter also presents strategies to address these challenges, emphasizing inclusive policymaking, interdisciplinary collaboration, and the development of robust governance structures. By prioritizing fairness, transparency, and accountability, this chapter argues that ethical AI systems can be effectively aligned with SDG objectives, fostering equitable and sustainable outcomes for all.

KEYWORDS

Ethical AI, Governance Challenges, Sustainable Development Goals (SDGs), Data Privacy, Algorithmic Bias

INTRODUCTION

Artificial Intelligence (AI) has emerged as a transformative force in the 21st century, with its applications reshaping industries and addressing complex global challenges. The United Nations' Sustainable Development Goals (SDGs), which aim to eradicate poverty, reduce inequalities, improve health and education, and promote sustainability, have seen AI playing a pivotal role in advancing these objectives. From using machine learning to predict climate risks to leveraging AI-driven diagnostics in healthcare, the technology's potential to accelerate progress toward achieving these goals is undeniable. However, as with any transformative technology, the deployment of AI introduces a host of ethical and governance challenges. While AI offers innovative solutions, it also risks exacerbating inequalities, infringing on privacy, and perpetuating biases if not governed responsibly. For example, AI systems trained on biased datasets can replicate and even amplify existing societal inequities, while unregulated data collection practices can violate individuals' privacy. These challenges underscore the importance of aligning AI development and deployment with ethical principles and robust governance frameworks, especially when applied to critical areas like poverty alleviation, healthcare, and education.

The Promise of AI in Achieving SDGs

AI's versatility makes it a valuable tool for addressing the multifaceted nature of the SDGs:

- **Zero Hunger (SDG 2):** Precision agriculture technologies use AI to optimize crop production, reduce waste, and combat food insecurity.
- **Good Health and Well-Being (SDG 3):** AI-driven medical diagnostics and wearable health technologies improve access to quality healthcare, particularly in underserved regions.
- **Quality Education (SDG 4):** Adaptive learning platforms powered by AI offer personalized educational content, catering to diverse learner needs.
- **Climate Action (SDG 13):** AI enables accurate climate modeling, helping policymakers implement effective strategies for environmental conservation.

While these applications demonstrate AI's immense potential, they also raise ethical concerns. For instance, AI tools used in healthcare must ensure patient confidentiality and avoid discriminatory practices, while adaptive learning platforms must ensure equitable access to resources for all students, including those in remote or disadvantaged regions.

The Ethical Challenges of AI in SDG Applications

AI applications often operate in sensitive domains involving human lives, rights, and livelihoods. As such, their deployment raises critical ethical concerns:

1. **Data Privacy:** AI systems require vast amounts of data to function effectively. However, in the process, personal and sensitive information can be mishandled or exploited. For example, welfare programs using AI to distribute benefits might inadvertently expose beneficiaries' private data.

2. **Bias and Fairness:** Bias in AI systems, whether stemming from flawed datasets or systemic inequalities, can lead to discriminatory outcomes. Such biases risk excluding marginalized communities from the very services AI aims to enhance.

3. **Transparency and Accountability:** As AI systems grow more complex, understanding how they make decisions becomes challenging. This lack of transparency raises concerns about accountability, especially in high-stakes scenarios like healthcare or criminal justice.

Governance Challenges in AI for SDGs

The rapid pace of AI development often outstrips the establishment of governance frameworks. This gap leads to several challenges:

- **Lack of Regulation:** Many countries, particularly in the Global South, lack the necessary policies to regulate AI systems effectively, leaving populations vulnerable to exploitation.
- **Unequal Representation:** Governance bodies often exclude stakeholders from developing nations, indigenous communities, or other marginalized groups, leading to solutions that may not address their unique needs.
- **Global vs. Local Approaches:** While global AI ethics frameworks like the UNESCO AI Recommendations provide valuable guidance, they must be adapted to local contexts to be effective.

Purpose and Structure of the Chapter

This chapter explores the ethical and governance challenges of deploying AI for SDG-related technologies. It addresses critical questions such as:

- How can AI systems ensure data privacy while delivering impactful solutions?
- What measures can mitigate bias and ensure fairness in AI applications?
- How can governance frameworks balance innovation with ethical responsibility?

Data Privacy in AI for SDGs

Data privacy is one of the most pressing ethical concerns in the development and deployment of AI, especially in its applications for Sustainable Development Goals (SDGs). As AI relies heavily on vast amounts of data to deliver accurate and actionable insights, ensuring the privacy and security of this data is crucial. In SDG applications—where data is often derived from vulnerable populations, such as marginalized communities, underserved regions, or individuals in crisis—privacy concerns are not merely technical; they are ethical and humanitarian issues. This section delves into the importance of data in AI systems, privacy challenges, regulatory frameworks, and strategies to safeguard privacy while maximizing AI's potential for SDG advancement.

2.1 The Importance of Data in AI Systems

AI's effectiveness depends on the quality, quantity, and diversity of the data it uses. In the context of SDGs, data enables AI systems to identify trends, predict outcomes, and personalize solutions across various domains, including healthcare, education, agriculture, and climate action.

Key Applications of Data in AI for SDGs:

1. **Healthcare (SDG 3):** AI-driven diagnostics rely on patient records, medical imaging, and real-time health monitoring data. For example, predictive analytics can detect outbreaks or identify early warning signs of diseases in underserved regions.

2. **Education (SDG 4):** AI-powered platforms analyze student performance data to provide personalized learning experiences, bridging educational gaps in remote or resource-constrained settings.

3. **Poverty Alleviation (SDG 1):** Economic data collected through AI helps governments identify at-risk populations and design targeted poverty reduction programs.

4. **Climate Action (SDG 13):** Environmental data, such as satellite imagery and sensor readings, helps AI models predict climate risks and optimize disaster response strategies.

Challenges in Data Utilization:

- Collecting reliable and diverse data in low-resource or conflict-prone regions.
- Ensuring data represents marginalized populations to avoid biased or incomplete AI solutions.

Example: In a healthcare AI initiative in Africa, incomplete datasets led to diagnostic tools that performed poorly for patients from rural communities compared to urban populations.

2.2 Privacy Concerns in AI Applications

The vast amounts of data required by AI systems inherently raise privacy concerns. This is particularly critical in SDG contexts, where data collection often involves sensitive information about individuals or communities.

Major Privacy Risks:

1. Mass Data Collection: Many AI systems, such as those used in welfare programs, require large-scale data gathering. However, this can inadvertently expose personal information to misuse or unauthorized access.

2. Inadequate Anonymization: Data anonymization techniques are not foolproof, and individuals can sometimes be re-identified, especially when datasets are combined.

3. Surveillance Risks: AI-powered monitoring tools, while useful for public safety or disaster management, risk being repurposed for intrusive surveillance, violating individual rights.

Real-World Examples:

- India's Aadhaar system, designed to improve welfare delivery through biometric identification, faced criticism for insufficient safeguards against data breaches and misuse.
- AI-driven credit scoring systems have been accused of using sensitive personal data, such as social media activity, without informed consent.

Impact on Vulnerable Populations:

Privacy breaches disproportionately affect vulnerable groups, such as refugees or low-income communities, who may have limited resources or legal recourse to address violations.

2.3 Regulatory Frameworks for Data Privacy

To address these concerns, robust data privacy regulations are essential. Several frameworks exist globally, but their application to SDG-focused AI systems requires specific considerations.

Global Data Privacy Laws:

1. General Data Protection Regulation (GDPR): The GDPR, implemented by the European Union, sets a high standard for data privacy and security, emphasizing informed consent, data minimization, and the right to be forgotten.
2. California Consumer Privacy Act (CCPA): The CCPA provides consumers with rights to access, delete, and control the use of their personal data, serving as a model for data privacy in the United States.
3. AI-Specific Guidelines: Organizations such as UNESCO and the OECD have proposed guidelines to address ethical AI deployment, including data privacy considerations.

Challenges in Developing Nations:

- Many countries in the Global South lack robust data privacy laws, leaving populations vulnerable to exploitation.
- Limited technical and financial resources make implementing and enforcing data protection regulations difficult.

Example: In several African nations, mobile money services rely on personal user data, but weak privacy regulations have led to concerns about data misuse by private companies.

The Need for Localization:

Global frameworks like GDPR must be adapted to local contexts to ensure they are practical and enforceable. For example, data privacy regulations for humanitarian AI systems should account for the unique challenges of crisis settings, such as refugee camps or disaster-stricken regions.

2.4 Strategies for Safeguarding Data Privacy in AI for SDGs

To address privacy concerns while leveraging the benefits of AI for SDGs, the following strategies can be implemented:

1. **Strengthening Data Governance:**
   Governments, organizations, and institutions must establish robust governance mechanisms to oversee data collection, storage, and usage.

- Implement clear policies for data ownership and accountability.
- Promote ethical data-sharing practices between stakeholders.

Case Study: The Open Data Charter initiative emphasizes ethical data sharing for public good while prioritizing privacy and security, serving as a model for SDG-focused projects.

2. **Improving Data Security Measures:**
   Advanced encryption, secure storage systems, and regular audits are crucial to prevent data breaches.

- Use technologies like blockchain to create immutable, secure data records.
- Conduct regular risk assessments to identify vulnerabilities.

Example: AI platforms in healthcare, such as those used for telemedicine, employ end-to-end encryption to protect patient information.

3. **Promoting Informed Consent:**
   Individuals must have clear, accessible information about how their data will be used and the ability to opt out.

- Simplify consent forms to ensure comprehension across diverse literacy levels.
- Provide opt-in mechanisms for data-sharing agreements.

Case Study: In Kenya, M-Pesa implemented an updated privacy policy requiring explicit user consent for data sharing, improving trust in the mobile money platform.

4. **Enhancing Technical Privacy Solutions:**
   Adopt cutting-edge techniques to protect privacy while enabling data analysis:

- **Differential Privacy:** Adds statistical noise to datasets, preserving individual anonymity while allowing useful insights.
- **Federated Learning:** Enables AI systems to train on decentralized data without transferring it to a central location, reducing privacy risks.

Example: Google has employed federated learning in its AI models for predictive text, ensuring user data never leaves individual devices.

5. **Encouraging Multi-Stakeholder Collaboration:**
   Governments, private companies, civil society, and academia must collaborate to create inclusive, context-sensitive privacy frameworks.

2.5 Balancing Privacy and AI Innovation

While safeguarding privacy is critical, excessive restrictions can hinder AI's potential for innovation and SDG progress. Finding a balance between these priorities is essential:

- **Trade-offs:** Strict data privacy laws may limit access to essential datasets, slowing AI development.

- **Solutions:** Encourage data-sharing partnerships where ethical and privacy standards are upheld, such as public-private collaborations that align with global ethical guidelines.

Example: AI for humanitarian aid often involves balancing privacy concerns with the urgency of saving lives. Organizations like the World Food Programme use anonymized data to ensure both safety and effectiveness in aid distribution.

Bias and Fairness in AI for SDGs

Bias and fairness are among the most significant ethical challenges in the application of Artificial Intelligence (AI). While AI has immense potential to drive progress toward the United Nations' Sustainable Development Goals (SDGs), its systems often reflect and perpetuate societal inequities. This is because AI models are trained on historical data, which may be incomplete, unrepresentative, or biased. When applied to sensitive domains like healthcare, education, and economic development, biased AI systems can lead to unfair outcomes, disproportionately affecting marginalized and vulnerable groups. This section explores the nature of bias in AI, its implications for fairness, real-world examples, and strategies to ensure equity in AI-driven SDG initiatives.

3.1 Understanding Bias in AI

Bias in AI occurs when an algorithm produces results that are systematically unfair or prejudiced toward certain groups. Bias can arise at various stages of AI system development, from data collection to model training and deployment.

Types of Bias in AI:

1. **Data Bias:** Occurs when training data is not representative of the population or task. For example, datasets used to train medical AI may overrepresent urban patients, neglecting rural communities.
2. **Algorithmic Bias:** Happens when the design of an algorithm unintentionally favors one group over another. For instance, a loan approval system may inadvertently favor men if trained on historical data reflecting gender disparities in credit access.
3. **Interaction Bias**: Introduced when users interact with AI systems in ways that reinforce existing stereotypes or behaviors.
4. **Societal Bias:** Reflects broader societal inequities that are embedded in data and systems, such as racial or gender discrimination.

Example: A facial recognition system trained predominantly on lighter-skinned individuals may perform poorly on darker-skinned individuals, leading to misidentifications and discriminatory outcomes.

3.2 The Importance of Fairness in AI for SDGs

Fairness in AI refers to the principle that AI systems should produce equitable outcomes, regardless of users' race, gender, socioeconomic status, or other characteristics. Ensuring fairness is particularly critical in SDG applications, as these systems often operate in high-stakes environments where decisions affect lives and livelihoods.

Why Fairness Matters for SDGs:

- **Healthcare (SDG 3):** Biased AI diagnostic tools can result in unequal access to quality healthcare, exacerbating health disparities between groups.
- **Education (SDG 4):** AI-driven learning platforms may favor students from privileged backgrounds if not designed inclusively, widening the education gap.
- **Economic Inclusion (SDG 8):** Unfair AI models in hiring or credit scoring can perpetuate discrimination against women, minorities, or low-income individuals.
- **Gender Equality (SDG 5):** AI systems must actively work to eliminate gender biases to support the empowerment of women and girls.

Real-World Implications:

Fairness in AI systems is not just a technical issue but a social one. A lack of fairness undermines the credibility of AI solutions, leading to mistrust among users and stakeholders. For AI to be a force for good, it must empower all communities equitably, not reinforce existing inequalities.

3.3 Case Studies: Bias and Its Impact

1. Healthcare Algorithms Favoring Wealthier Patients:

A study found that an AI tool used to prioritize healthcare interventions in the United States systematically underrepresented Black patients. Despite equal levels of illness, Black patients were less likely to be flagged for additional care because the algorithm relied on historical healthcare expenditure, which was lower for Black populations due to systemic disparities.

2. **Gender Bias in Hiring Algorithms:**

A large technology company developed an AI system to screen job applicants. The system favored male candidates because it was trained on historical data reflecting a male-dominated workforce. Female candidates were penalized for including terms like “women’s” in their resumes.

3. **Facial Recognition in Law Enforcement:**

Facial recognition systems have shown significant racial biases, with higher error rates for people of color. These inaccuracies have led to wrongful arrests, particularly in communities already vulnerable to systemic bias.

4. **Credit Scoring Models Excluding Marginalized Groups:**

AI-driven credit scoring systems often rely on indirect factors, such as ZIP codes or internet activity, that can disadvantage low-income or minority groups. This perpetuates financial exclusion, counteracting efforts to achieve economic equality.

3.4 Addressing Bias in AI for SDGs

To ensure fairness and reduce bias, organizations and stakeholders must adopt proactive measures throughout the AI lifecycle.

Strategies to Mitigate Bias:

1. **Diverse and Representative Data:**

- Collect datasets that reflect the diversity of the target population.
- Regularly audit datasets to identify and rectify imbalances.
- Include data from underrepresented regions, such as rural areas or developing countries, to avoid exclusion.

Example: A global health initiative ensured representation from multiple regions when training AI tools to detect malaria, improving accuracy for diverse populations.

2. Bias Detection and Testing:

- Use fairness metrics to evaluate AI systems for bias before deployment.
- Implement tools like IBM's AI Fairness 360, which identifies and mitigates algorithmic bias.

Case Study: A social welfare AI system was redesigned after fairness tests revealed that it disproportionately flagged individuals from low-income neighborhoods for fraud investigations.

3. Human Oversight:

- Combine AI decision-making with human judgment to identify and correct unfair outcomes.
- Train human operators to recognize and address AI biases.

Example: In AI-powered hiring, human reviewers ensure that automated shortlists are inclusive and free from discriminatory patterns.

3.5 Governance Frameworks for Fair AI

Bias and fairness in AI cannot be addressed without robust governance frameworks. These frameworks provide the structure needed to develop and deploy AI systems ethically.

Key Governance Practices:

1. Regulation and Policy:

Governments must enforce laws to prevent discriminatory practices in AI systems. Policies should mandate bias audits for high-stakes AI applications, such as healthcare or criminal justice.

Example: The EU's proposed AI Act includes provisions to address high-risk AI systems and their impact on fundamental rights.

2. Ethical Guidelines:

Organizations like UNESCO and the IEEE have developed guidelines to ensure ethical AI deployment. These frameworks emphasize fairness, accountability, and inclusivity in AI systems.

3. Public-Private Collaboration:

Partnerships between governments, private companies, and civil society can drive the development of fair AI systems by pooling resources and expertise.

Example: Initiatives like AI4Good promote collaborative approaches to developing AI for sustainable development.

4. Global Standards:

Developing international standards for fairness in AI can help ensure consistency across regions and sectors. These standards should account for cultural and contextual differences, ensuring global applicability.

3.6 Moving Toward Equitable AI for SDGs

Bias and fairness are not static challenges; they evolve as AI systems and societal contexts change. Achieving fairness in AI for SDGs requires a continuous commitment to learning, adaptation, and collaboration.

Balancing Innovation and Equity:

- AI innovation must prioritize inclusivity and fairness over efficiency or profit.
- Developing nations must be empowered with resources and knowledge to implement fair AI solutions.

Empowering Marginalized Communities:

AI should be designed to uplift the voices of marginalized communities, ensuring they are not just beneficiaries but active participants in the design and governance of AI systems.

By addressing bias and promoting fairness, AI can truly serve as a tool for equitable progress toward the SDGs.

Governance Challenges in AI for SDGs

Governance is the cornerstone of ensuring that Artificial Intelligence (AI) is developed and deployed responsibly to advance the United Nations' Sustainable Development Goals (SDGs). Effective governance involves creating policies, frameworks, and institutions that oversee the ethical use of AI. However, given the global scale, diversity of contexts, and rapid evolution of AI technologies, governance faces numerous challenges. These challenges include ensuring inclusivity, managing regulatory disparities, addressing the lack of global coordination, and establishing accountability mechanisms. This section explores these governance challenges in detail, highlighting their implications for achieving SDGs and proposing potential pathways for improvement.

4.1 Fragmentation of AI Governance Frameworks

The governance of AI is currently fragmented, with no universally accepted framework or regulatory body to oversee its use across different regions and sectors. This poses significant challenges for SDG-focused applications, which often operate on a global scale.

Key Issues:

1. **Inconsistent Policies:** Countries and regions have varying levels of regulation for AI, creating inconsistencies. For example, while the European Union's proposed AI Act emphasizes ethical AI use, many developing nations lack comprehensive AI policies.

2. **Cross-Border Data Challenges:** Many SDG initiatives rely on cross-border data sharing. Without harmonized governance, managing issues like privacy, security, and intellectual property rights becomes complex.
3. **Sector-Specific Regulations:** AI governance often varies by sector, with healthcare, finance, and education governed by different rules. This sectoral fragmentation complicates the application of AI to interlinked SDGs.

Implications for SDGs:

Fragmented governance creates barriers to collaboration, slows down innovation, and increases risks of misuse. For example, AI systems designed for global health initiatives may face regulatory delays due to differing compliance standards across countries.

4.2 Lack of Inclusivity in Governance

AI governance often excludes critical stakeholders, particularly from marginalized communities and developing nations. This exclusion undermines the ability of AI to address the SDGs equitably.

Challenges:

1. **Representation Gaps:** Policy-making processes are often dominated by high-income countries and large technology companies, sidelining voices from low-income regions where many SDG challenges are most acute.
2. **Digital Divide:** Developing nations face barriers to participating in AI governance due to limited resources, technical expertise, and infrastructure.
3. **Community Engagement:** AI governance rarely includes input from the communities most affected by AI systems, leading to policies that may not reflect their needs or values.

Implications for SDGs:

Without inclusivity, AI systems risk perpetuating inequalities. For instance, rural and indigenous communities may be excluded from AI-driven healthcare or education initiatives due to governance frameworks that prioritize urban-centric solutions.

4.3 Accountability in AI Deployment

One of the critical governance challenges is establishing accountability mechanisms for AI systems, particularly in the context of SDG applications, where mistakes can have severe consequences.

Accountability Challenges:

1. **Opaque Algorithms:** Many AI systems operate as “black boxes,” making it difficult to trace decisions or identify responsibility for errors.

2. **Diffused Responsibility:** AI projects often involve multiple stakeholders, including governments, NGOs, and private companies. This diffusion of responsibility can lead to accountability gaps when something goes wrong.

3. **Regulatory Lag:** Governance frameworks often fail to keep pace with AI advancements, leaving gaps in oversight.

Case Study: In an AI-driven welfare distribution system, algorithmic errors wrongly flagged eligible beneficiaries as ineligible. The lack of clear accountability mechanisms left affected individuals with no recourse for redress.

Implications for SDGs:

Accountability failures can undermine trust in AI systems and derail progress toward SDGs. For example, a lack of accountability in AI-based disaster response tools could lead to loss of life or misallocation of resources.

4.4 Balancing Innovation and Regulation

Governance frameworks must strike a delicate balance between fostering innovation and ensuring ethical use of AI. Overregulation can stifle progress, while under regulation increases the risk of misuse.

Governance Tensions:

1. **Restrictive Regulations:** Strict governance may discourage private sector investment in AI for SDGs, particularly in sectors like agriculture or healthcare.
2. **Innovation Hubs vs.** Developing Nations: High-income countries often become hubs for AI innovation, while developing nations face barriers due to overregulation or lack of incentives for AI adoption.
3. **Ethical Trade-Offs:** In some cases, rapid AI deployment is prioritized over ethical considerations, such as privacy and fairness. For example, during a pandemic, AI-driven contact tracing tools may bypass privacy norms in the name of public health.

Implications for SDGs:

Balancing innovation and regulation is critical to advancing SDGs. Overregulation could limit the availability of AI tools in low-resource settings, while underregulation could lead to harm or exploitation in vulnerable communities.

4.5 Global Coordination and Standardization

Achieving SDGs often requires international collaboration, but the lack of global coordination in AI governance creates significant challenges.

Coordination Challenges:

1. **Differing Priorities:** High-income countries may prioritize issues like AI-driven industrial automation, while low-income nations focus on AI for poverty alleviation or basic healthcare.
2. **Global Standards:** The absence of universally accepted ethical standards for AI leads to discrepancies in how technologies are deployed and regulated.
3. **Geopolitical Tensions:** Rivalries between major AI players, such as the United States and China, hinder collaborative efforts to establish global governance frameworks.

Potential Solutions:

1. Create international bodies to oversee AI ethics and governance, similar to the International Atomic Energy Agency (IAEA).
2. Develop global certification standards for AI systems, ensuring that they meet ethical benchmarks regardless of their country of origin.
3. Promote open collaboration through initiatives like the AI for Good Summit, which brings together diverse stakeholders to address global challenges.

Implications for SDGs:

Without global coordination, AI systems risk duplicating efforts, perpetuating inequalities, or even conflicting with each other. For example, differing approaches to data privacy could undermine cross-border healthcare initiatives.

Case Studies of Ethical AI in SDG Applications

AI technologies have emerged as powerful tools for addressing the United Nations' Sustainable Development Goals (SDGs). However, their application is accompanied by significant ethical considerations, such as ensuring fairness, transparency, and inclusivity. This section explores real-world case studies where ethical AI has been successfully deployed to advance specific SDGs, demonstrating how ethical frameworks can enable impactful and equitable outcomes.

Case Study 1: AI for Financial Inclusion (SDG 8)

Project: Kiva Protocol for Digital Identity in Sierra Leone
Objective: To provide marginalized populations with access to financial services by leveraging AI and blockchain technologies.
Key Ethical Considerations: Bias mitigation, data security, and informed consent.

Description:

Kiva, a global non-profit organization, collaborated with the government of Sierra Leone to implement a digital identity platform powered by AI and blockchain. The system provides citizens with verifiable digital identities, enabling them to access loans, savings accounts, and other financial services.

Ethical Approach:

1. **Bias Mitigation:** AI algorithms were tested to ensure fairness across gender, ethnicity, and socioeconomic groups.
2. **Data Security:** Blockchain technology was used to protect user data and prevent unauthorized access.
3. **Informed Consent:** Citizens were educated about the platform's features and given control over how their data was used.

Impact:

- Over 500,000 citizens gained access to financial services within three years.
- Increased economic opportunities for women and small business owners.
- Strengthened trust in digital financial systems through ethical practices.

Key Lessons:

Ethical deployment of AI, particularly in financial systems, can help bridge economic gaps and promote inclusive growth.

Case Study 2: AI for Disaster Response (SDG 11)

Project: Google AI for Flood Prediction in South Asia
Objective: To improve disaster preparedness and minimize the impact of floods in vulnerable regions.
Key Ethical Considerations: Accuracy, equity, and community engagement.

Description:

Google AI developed a flood prediction tool that uses machine learning models to forecast riverine floods. The system integrates satellite data, hydrological models, and historical weather patterns to provide early warnings to at-risk communities in India and Bangladesh.

Ethical Approach:

1. Accuracy: The AI model was trained and validated with extensive datasets to ensure reliable predictions.

2. Equity: Efforts were made to ensure that warnings reached marginalized groups, such as those in remote areas or without internet access.

3. Community Engagement: Local governments and NGOs were involved in disseminating warnings and educating communities about flood preparedness.

Impact:

- Timely warnings allowed 2 million people to evacuate safely during severe floods in 2020.
- Reduction in flood-related casualties and property damage.
- Increased resilience in vulnerable communities through awareness and preparedness initiatives.

Key Lessons:

Ethical AI, when combined with local engagement, can significantly enhance disaster response and resilience.

These case studies demonstrate that ethical AI is not just a theoretical ideal but a practical necessity for achieving the SDGs. By prioritizing fairness, transparency, inclusivity, and accountability, organizations can harness AI's transformative potential to create equitable and sustainable solutions for global challenges.

Building Ethical AI for Sustainable Development

As Artificial Intelligence (AI) becomes a critical enabler in advancing the United Nations' Sustainable Development Goals (SDGs), the importance of integrating ethics into AI development and deployment cannot be overstated. Ethical AI ensures that technology is fair, inclusive, accountable, and aligned with the values of sustainability and equity. Building ethical AI for sustainable development requires addressing systemic challenges in data, algorithms, governance, and societal impacts while fostering a collaborative approach among stakeholders.

This section explores key principles, strategies, and frameworks for designing and implementing ethical AI systems that effectively contribute to sustainable development.

Key Principles for Ethical AI Development

Ethical AI for sustainable development is guided by several fundamental principles:

1. **Fairness and Equity:** AI systems must address disparities by avoiding biases in algorithms and ensuring equitable access to AI technologies, especially for underserved populations. For example, AI tools used in healthcare must provide accurate diagnoses across diverse demographic groups.
2. **Transparency and Explainability:** AI systems must be transparent in their decision-making processes, enabling stakeholders to understand and trust their outputs. This is particularly critical in high-stakes sectors such as justice, finance, and public health.
3. **Accountability:** Developers, organizations, and governments must take responsibility for the social and environmental impacts of AI technologies. Mechanisms for redress and correction should be in place to mitigate unintended harm.
4. **Sustainability:** AI systems must be designed with environmental considerations, minimizing energy consumption and supporting climate-resilient solutions.
5. **Inclusivity:** AI initiatives should involve diverse stakeholders, ensuring that the voices of marginalized communities are represented in decision-making processes.

Frameworks for Ethical AI in SDG Applications

Building ethical AI requires structured frameworks that integrate ethical considerations throughout the AI lifecycle.

1. **Data Collection and Management:**
    - Diversity in Data: Ethical AI begins with collecting diverse datasets that represent the populations it serves. This helps minimize biases and ensures the system's applicability across different contexts.
    - **Privacy Protection:** Data used in AI systems must be collected with informed consent and safeguarded against misuse. Adherence to privacy laws such as the General Data Protection Regulation (GDPR) sets a global benchmark for ethical data practices.

2. **Algorithm Design and Testing:**
    - Bias Audits: Algorithms should be rigorously tested for biases to prevent systemic discrimination. Techniques like adversarial testing and fairness metrics can identify and address disparities in AI decision-making.
    - Explainable AI (XAI): By developing models that provide interpretable outputs, organizations can ensure that AI systems remain understandable and trustworthy for end-users.
3. Deployment and Monitoring:
    - Stakeholder Engagement: Ethical AI deployment requires collaboration with governments, non-profits, and communities to align AI solutions with local needs and values.
    - Impact Assessment: Continuous evaluation of AI systems ensures that they contribute positively to SDGs without causing unintended harm. For instance, AI systems used in disaster response must be regularly updated to incorporate new data and feedback.

Challenges and Opportunities

While the integration of ethics into AI development presents challenges—such as balancing innovation with regulation, managing resource constraints, and addressing cultural differences—it also creates opportunities for transformative impact. Ethical AI has the potential to amplify the benefits of technology while minimizing risks, enabling equitable and sustainable solutions for pressing global issues.

By prioritizing ethical principles, frameworks, and strategies, stakeholders can harness AI's power to create systems that advance sustainable development while respecting human rights, diversity, and environmental stewardship.

Future Directions in Ethical AI for SDGs

The role of Artificial Intelligence (AI) in advancing the Sustainable Development Goals (SDGs) is poised to grow exponentially in the coming years. However, the path forward necessitates a proactive focus on ethical considerations to ensure AI technologies are deployed responsibly, inclusively, and sustainably. Future directions in ethical AI for SDGs will center on addressing emerging challenges, fostering global cooperation, and leveraging technological advancements for equitable progress. This section explores key areas of focus and potential strategies to shape the future of ethical AI for sustainable development.

1. Developing Global Ethical Standards for AI

AI development and deployment currently lack universally accepted ethical guidelines. The future of ethical AI for SDGs will depend on the establishment of global standards that align with principles of fairness, transparency, and accountability.

- Unified Ethical Frameworks: International bodies such as the United Nations, the International Telecommunication Union (ITU), and the OECD could lead efforts to create standardized ethical guidelines for AI development. These frameworks

should be flexible enough to account for regional and cultural diversity while ensuring universal adherence to human rights and sustainability principles.

- Cross-Border Regulatory Collaboration: Countries must collaborate to harmonize AI regulations, particularly in areas like data privacy, algorithmic transparency, and intellectual property rights. This will help facilitate the global deployment of AI solutions for SDGs while mitigating risks such as cross-border data misuse.

2. Strengthening AI for Equity and Inclusion

Future ethical AI initiatives must prioritize equity and inclusion to ensure that no one is left behind in the pursuit of the SDGs.

- AI for Underserved Communities: Efforts should focus on extending the benefits of AI to marginalized populations, including rural communities, indigenous groups, and low-income nations. For example, AI-driven healthcare systems should be adapted for resource-constrained settings to address global health disparities (SDG 3).

- Reducing Algorithmic Bias: As AI adoption grows, so does the need to address biases embedded in algorithms. Future directions will include the development of robust bias-detection tools and frameworks for ensuring fairness across all demographic groups.

- Digital Literacy and Capacity Building: Investments in education and training programs will empower underrepresented groups to participate in AI development and governance, fostering inclusivity in the global AI ecosystem.

3. Integrating AI Ethics into Education and Research

Education and research are critical to advancing ethical AI for sustainable development.

- Curriculum Development: Universities and technical institutions should incorporate AI ethics into their curricula, training future developers, policymakers, and researchers to understand the societal implications of AI.
- Interdisciplinary Research: Future research should bridge the gap between technology and ethics by fostering collaboration among computer scientists, social scientists, ethicists, and policymakers. For instance, interdisciplinary teams could explore the intersection of AI, climate change, and social equity (SDG 13).
- Open Research Platforms: Ethical AI research should emphasize transparency and inclusivity by leveraging open-access platforms that enable knowledge sharing among diverse stakeholders.

4. Advancing AI Governance Mechanisms

Ethical AI for SDGs will require the evolution of governance mechanisms to address emerging challenges and complexities.

- Dynamic Policy Frameworks: Governance frameworks must adapt to rapidly changing AI technologies. Future policies should include mechanisms for continuous monitoring and updating of regulations to keep pace with innovation.
- Participatory Governance Models: Governance systems should include diverse stakeholders, including governments, private companies, non-profits, and affected communities, to ensure that policies reflect a broad range of perspectives.

- AI Accountability Systems: Future governance structures will need robust accountability mechanisms to address ethical breaches, such as algorithmic discrimination or data misuse. This could involve independent oversight bodies or AI ethics boards.

CONCLUSION

Ethical and governance challenges are at the forefront of integrating Artificial Intelligence (AI) into achieving the United Nations' Sustainable Development Goals (SDGs). While AI has the potential to accelerate progress across sectors such as healthcare, education, climate action, and financial inclusion, its deployment raises critical ethical concerns. Issues such as data privacy, algorithmic bias, fairness, and accountability require urgent attention to ensure that AI systems promote equity and sustainability rather than exacerbate existing inequalities. Addressing these challenges demands a collaborative approach. Policymakers, developers, businesses, and civil society must work together to create robust ethical frameworks and governance mechanisms. Transparency, inclusivity, and accountability must guide the entire AI lifecycle, from data collection to deployment and beyond. Establishing global standards and fostering interdisciplinary collaboration will be essential in mitigating risks and maximizing the benefits of AI for sustainable development. Ultimately, aligning AI with ethical principles and sound governance is not just a technological imperative but a moral and social one. By prioritizing fairness, protecting individual rights, and ensuring equitable access to AI technologies, we can harness the transformative power of AI to create a more inclusive, just, and sustainable future for all.

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CHAPTER 6

ENHANCING CONTRACTOR PERFORMANCE IN VIEW OF URBAN INFRASTRUCTURE PROJECTS IN KENYA: WHAT IT MEANS BY SKILLED MANPOWER IN THE ERA OF ARTIFICIAL INTELLIGENCE

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ABSTRACT

Skilled manpower is indispensable in the 21st century to open doors for industrialization in the African continent. Kenya has invested heavily on infrastructure development and this calls for immediate upscaling of skills among her youth and construction workforce. The purpose of this study was to establish the significance of skilled manpower on performance of contractors in infrastructure projects particularly within the road construction sector in Kenya. The two designs used were survey and correlation. A total of 156 informed the target population from which a sample size of 62 was obtained comprising road contractors, engineers working within the road authorities, consultants in the road sector and technical auditors. This was done using the stratified-proportionate sampling technique. Through correlation analysis, the relationship was established to be positive, significant and moderately strong relationship between the

independent and dependent variables. The findings from Analysis of Variance (ANOVA) revealed that for a unit increase in skilled manpower, contractors' performance would increase by 0.225 in road construction sector equivalent to 23%. Study findings reveal that AI in the Kenyan market is hampered in various ways: it is costly, AI is not fully embraced because of the diverse profession, expensive maintenance licenses, analytical practice, lack of curriculum in schools and colleges to train and nurture technical capacity on AI. Results from the interviews on the level of AI adoption and utilization in Kenya indicated: 12% of construction professional perceive AI as moderately adopted, 59% is adopted to a small extent and 29% said they have neither adopted nor utilized AI. The study recommends that contractors should endeavor to employ skilled manpower and build capacity of the existing ones through adoption of Artificial Intelligence (AI) so as to enhance performance with a view of ensuring timely, cost-effective and quality completion of road projects. This in turn will lead to improved quality of life for urban dwellers. The study contributes to body of knowledge in construction particularly the need to develop AI skills for industrialization in Kenya and also project management of government funded road and other infrastructure projects.

Keywords: *Road contractors, skilled manpower, skilled labour, contractor performance, urban infrastructure projects, road construction, Artificial Intelligence*

1. INTRODUCTION

A construction project is commonly considered to be successful, when it is completed on time, within budget and in accordance with the specifications (Cunningham, 2017; Thorat, Khandar & Kanase, 2017). There is no congruent correlation on what performance is and the traditional iron triangle of “cost-time-quality” is still the preferred method of analysing performance, despite it being proven to be ineffective (Mellado, Lou & Becerra, 2019). Poor performance and late project completion in road construction industry has been a global phenomenon with the most affected being the developing countries (Aftab, Ismail & Ade, 2012;Tawil et al., 2013; Ali, Smith, Pitt & Choon, 2010; Ansah, 2011; Bilau, Ajagbe, Habila & Sholanke, 2015).

A total of 17.3% construction projects in Malaysia experience delay that is partly caused by labour shortage (Ali *et al.*, 2010). The shortage of skilled labour in construction firms can be resolved by encouraging commitment of the few available ones so as to influence service delivery. A study by Aghimien, Awodele and Maipompo (2018) revealed that the common type of commitment exhibited by skilled construction workers is the continuance commitment. Factors such as getting feedback from supervisors, payment received being equal to work done, and the availability of opportunities to grow, play a major role in the commitment type being exhibited. Similarly, an exploratory study on the possible causes and effects of delay in residential projects in India revealed that lack of skilled manpower was one of the greatest causes of delayed completion in the construction sector (Thorat et al., 2017). Researchers therefore agree that there is need to hire skilled workers to be able to achieve good progress of work, avoid poor quality of work, more rectification and double handling (Thorat et al., 2017; Aftab et al., 2012; Ali et al., 2010).

A detailed review of archival documents aimed at examining the shortage of skilled craftsmen in the construction industry, particularly in small and medium construction firms in Nigeria added to existing body of knowledge by exposing the reasons for shortage of skilled craftsmen in the construction industry (Bilau, *et al*., 2015). The review further showed that the concept of shortage of skilled craftsmen is not a shortage of workers but

rather, a shortage of well trained, skilled, and productive workers available for certain jobs. Some additional reasons attributed for such shortage are lack of training and retraining opportunities, an aging workforce, and the construction industry that does not appeal to the younger generation.

A study carried out in Congo with the aim of identifying, evaluating and classifying the most significant Key Performance Indicators (KPI's) that affect construction, using the Relative Importance Index (RII), revealed that the most important factors affecting Congolese construction projects were design, client management, contractor productivity, scheduling, and the contract. The experience and skill of the design team were found to affect the design-related factors (Bitamba & An, 2020). Another study in Malaysia found that 92% of construction projects were overrun and only 8% of projects could be completed within the planned contract duration (Aftab, *et al*., 2012). This also was associated with skilled manpower that affected the contractors' performance.

In Kenya, only 20.8 per cent of the projects are implemented on time and budget, while 79.2 per cent exhibited some form of failure (Nyika, 2012). The major causes of failures were insufficient implementing capacity, poor project management, weak project design and political interference. Therefore, factors influencing performance of contractors are very critical to any construction firm.

Fundamentally, gaps in skills and adoption of modern technology are blamed for the poor performance of the contractors. For instance, Owesi (2021) notes that the Kenyan construction industry is picking up with the trends of technology with several firms keen to apply advanced technology in planning, costing and packaging their projects. He goes on to say that designers, project managers and other experts therefore have a reason for concern when the bulk of construction processes are still very manual and disjointed; a recipe that delivers food whose ingredients cannot be authenticated.

While interest in AI is growing, Kenyan enterprises face several challenges. Major obstacles include a lack of skills, data security threats, and ethical issues (Chege, 2024). To support the quantitative processes primarily associated with scope, schedule, cost, quality, and risk management, Holzmann and Michele (2022) carried out a global survey

in the construction industry and found that project practitioners are searching for AI solutions. They noted that lack of knowledge and skills are barriers to adopting AI in construction project management. To determine the training requirements of Kenyan construction workers, the National Construction Authority (2022) carried out research.

The study found that the construction industry has knowledge and skill gaps that can be filled by worker training. The authority said in the report that individuals who enter the construction industry informally should receive basic training. Thus, need for onsite training (Wandia and Ralwala, 2024). For instance, a study by Nasila and Cloete (2018), found that the Kenyan construction industry is still lagging in the adoption of Building Information Modelling (BIM), an Artificial Intelligence (AI) technology. The authors cite lack of training for architects and engineers, due to costly training requirements in terms of time and money. This results in inadequate information coordination amongst stakeholders in construction projects. Statistics indicate that Kenya was ranked the 9th African country best prepared for AI adoption in 2023 and 101st goblally (Azaroual, 2024). Although all these studies cite the need for skilled manpower, and lack of it, in the Kenyan construction industry, there exists a gap to empirically demonstrate the association between skilled manpower in Kenyan construction industry and performance of infrastructural projects hence the need to carry out our study.

The aim of the current study was to investigate the impact of skilled manpower on contractor performance in road construction industry in Kenya. The study also investigated the level of adoption of artificial intelligence (AI) with respect to tools used and areas where AI is being applied. In addition the challenges that construction professional encounter were explored and their opinion sought on suggestions for the way forward. This study was therefore guided by both null (H_0) and alternate (H_1) hypotheses. H_0: There is no relationship between skilled manpower and contractor performance. H_1: There is a relationship between skilled manpower and contractor performance.

2. LITERATURE REVIEW

Literature shows that delay in project completion has been a subject of concern to various researchers for decades. Since delay is directly associated with cost and time overrun, thus it is a matter of concern for stakeholders in the construction sector. Some of the studies in various contexts are covered in this section. Theoretical review is also covered to support the study objective.

2.1 Theoretical Review

This section presents theories that support the study. These are human capital theory and diffusion of innovation theory:

2.1.1 Human Capital theory

The human capital theory was founded by Schultz in 1961 and subsequently refined by Gary S. Becker following his seminal work titled “employer-provided training economics” of 1962 and 1964 (Fugar, Ashiboe-Mensah & Adinyira, 2013). The theory is grounded on the premise that capacity building has the potential to inculcate assets of critical knowledge to workers, and as a result increase their income and productivity. Becker listed types of capital; specific and general human capital. On one hand, specific human capital is technology achieved through capacity building initiatives, with aim of addressing particular skill needs.

On the other hand, general human capital refers to knowledge acquired via capacity building initiatives but whose value transcends contextual differences, for example, literacy skills. The concept of human capital encompasses the skills, knowledge and abilities of people Bohlander, Snell & Sherman, 2001). This definition rhymes with the definition of Organization for Economic Co-operative and Development (OECD) that human capital is a bundle of knowledge, skills-sets, competencies and characteristics within an individual that enhance the personal development, economic and social welfare (OECD, 2001). The theory is borrowed in this study because it emphasizes on the importance of skills for the construction teams and a prerequisite for development of infrastructure projects.

2.1.2 Diffusion of Innovation Theory

This theory was propounded in 1962 by Everett .M. Rogers (Rogers, 1995). The Diffusion of Innovation (DOI) Theory is one among the oldest theories in social science. According Lamorte (2019), it originated in communication to explain how, over time, an idea or product gains momentum and diffuses (or spreads) through a specific population or social system. The end result of this diffusion is that people, as part of a social system, adopt a new idea, behavior, or product. Adoption means that a person does something differently than what they had previously (i.e., purchase or use a new product, acquire and perform a new behavior, etc.). The key to adoption is that the person must perceive the idea, behavior, or product as new or innovative. It is through this that diffusion is possible.

Adoption of a new idea, behavior, or product (i.e., "innovation") does not happen simultaneously in a social system; rather it is a process whereby some people are more apt to adopt the innovation than others. Lamorte (2019) noted that people who adopt an innovation early have different characteristics than people who adopt an innovation later. When promoting an innovation to a target population, it is important to understand the characteristics of the target population that will help or hinder adoption of the innovation. The five stages of innovation adoption are illustrated in Figure 1:

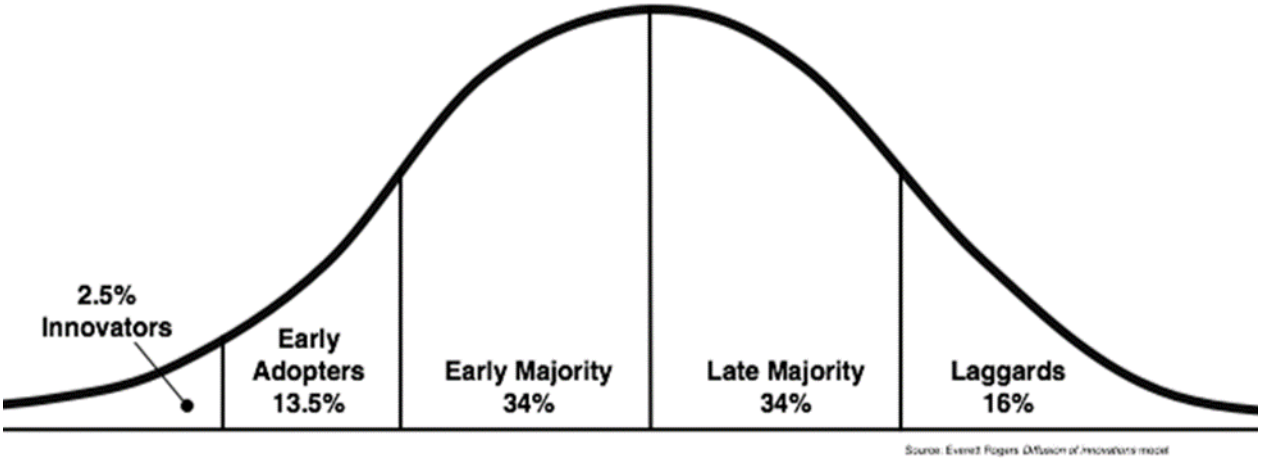

Figure 1. Five stages of Innovation Adoption

Source:https://sphweb.bumc.bu.edu/otlt/mphmodules/sb/behavioralchangetheories/behavioralchangetheories4.html

There are **five established adopter categories**, and while the majority of the general population tends to fall in the middle categories, it is still necessary to understand the characteristics of the target population. When promoting an innovation, there are different strategies used to appeal to the different adopter categories (Lamorte, 2019).

1. **Innovators** - These are people who want to be the first to try the innovation. They are venturesome and interested in new ideas. These people are very willing to take risks, and are often the first to develop new ideas. Very little, if anything, needs to be done to appeal to this population.

2. **Early Adopters** - These are people who represent opinion leaders. They enjoy leadership roles, and embrace change opportunities. They are already aware of the need to change and so are very comfortable adopting new ideas. Strategies to appeal to this population include how-to manuals and information sheets on implementation. They do not need information to convince them to change.

3. **Early Majority** - These people are rarely leaders, but they do adopt new ideas before the average person. That said, they typically need to see evidence that the innovation works before they are willing to adopt it. Strategies to appeal to this population include success stories and evidence of the innovation's effectiveness.

4. **Late Majority** - These people are skeptical of change, and will only adopt an innovation after it has been tried by the majority. Strategies to appeal to this population include information on how many other people have tried the innovation and have adopted it successfully.

5. **Laggards** - These people are bound by tradition and very conservative. They are very skeptical of change and are the hardest group to bring on board. Strategies to appeal to this population include statistics, fear appeals, and pressure from people in the other adopter groups.

One common limitation associated with the DOI theory is that it does not take into account an individual's resources or social support to adopt the new behavior (or innovation).

Straub (2009) observed that technology adoption is a complex, inherently social, developmental process; individuals construct unique yet malleable perceptions of technology that influence their adoption decisions. Thus, successfully facilitating technology adoption must address cognitive, emotional, and contextual concerns. There are **five main factors that influence adoption of an innovation**, and each of these factors is at play to a different extent in the five adopter categories.

1. **Relative Advantage** - The degree to which an innovation is seen as better than the idea, program, or product it replaces.

2. **Compatibility** - How consistent the innovation is with the values, experiences, and needs of the potential adopters.

3. **Complexity** - How difficult the innovation is to understand and/or use.

4. **Triability** - The extent to which the innovation can be tested or experimented with before a commitment to adopt is made.

5. **Observability** - The extent to which the innovation provides tangible results.

2.2 Empirical Literature Review

This section focuses on the empirical literature detailing information on aspects of contractor performance, skilled manpower and training, and finally, adoption of artificial intelligence (AI) in infrastructure projects.

2.2.1 Gaps in Contractor performance

Performance measurement has been a subject of discussion in most of research over the past decades (Zidanea *et al*., 2016). Different contexts have produced related challenges for project completion with small contextual differences. A study in India, determined shortage of skilled manpower and labour and also demonstrated that the effects of project delay are cost and time overrun (Thorat *et al*., 2017). On top of this was poor project quality. Among the delay factors identified that impact on completion of the project in Malaysian construction industry includes contractors' improper planning and shortage of labor supply (Sambasivan and Soon, 2007). A study by Sweis *et al*. (2014)

revealed that apart from financial difficulties faced by the contractor, manpower shortages (of skilled, semi-skilled, or unskilled labor) was among the top leading factors directly affecting contractor performance on construction projects.

Owesi (2021) opines that most projects in Kenya are usually faced with the time and cost overruns, thus the application of technology can be useful to solve these issues ultimately affecting project delivery. Beside these Key Performance Indicators (KPI's), construction small and medium firms should also use supply chain management and employee satisfaction since these measures can impact positively on firms' performance (Tunji-Olayeni, *et al*., 2016). It is also revealed that contractors' poor performance is a result of delayed payment (Alinaitwe, 2008). This in turn affects contractors' ability to offer training and hiring of qualified personnel.

Potential Consequences of Failing to Address the Skills Shortage:

Delayed Infrastructure Projects: The shortage of skilled workers can significantly delay the completion of infrastructure and general construction projects. With insufficient workforce resources, projects may face extended timelines, leading to increased costs and disruptions in the overall development of critical infrastructure.

Increased Costs: The demand for skilled workers outstrips supply, resulting in higher labour costs. This can inflate project budgets, making them financially unviable or requiring cuts in other essential areas.

Quality Compromises: A lack of skilled workers can lead to compromised quality in construction projects. This can have long-term implications for the durability, functionality, and safety of the project, posing risks to public welfare.

Reduced Competitiveness: A shortage of skilled workers can make the construction industry less competitive on a global scale. This can limit economic growth and hinder the development of a robust and sustainable construction sector.

As already aforementioned, the current study focused on skilled manpower. A study on

assessment of clients' performance in having an efficient building process in Uganda revealed that lack of support for training the workers affected contractors' performance (Alinaitwe, 2008).

2.2.2 Skilled Manpower and Training

The international Labour Office (ILO) indicated that among the cornerstones of a policy framework for developing a suitably skilled workforce broad availability of good-quality education as a foundation for future training and a close matching of skills supply to the needs of enterprises and labour markets International Labour Office (2010). Besides Consultant related, Owner related, design related, material, equipment, external related factors, there are also labour related factors that have affected construction performance. Udasi and Darade found that delays in the construction projects are influenced by labour related factors such as low skilled, productivity level or unqualified labours (Udasi & Darade, 2018). Mushori, Rambo and Wafula maintain that most of the construction contractors do not operate with management teams that meet minimum requirement as far as experience is concerned (Mushori, Rambo & Wafula, 2020). On the other hand, Akomah and Jackson add that the contractors' performance is linked to unskilled equipment operators (Akomah & Jackson, 2016).

Construction industry require highly skilled workforce to do some of the most dangerous jobs, replacement and recruitment proves to be difficult (Oseghale, Abiola-Falemu & Oseghale, 2015). Many studies have linked the lack of skilled manpower as a major impediment to contractor performance in the construction sector in different contest. These include residential construction industry (Thorat et al., 2017; Olsen,Tatum & Defnall, 2012). However, the lack of skilled manpower must not be confused with the lack of labour (Bilau et al., 2015). The results from Hussain, Xuetong and Hussain study revealed that unskilled labor had a negative correction thus impacting negatively on project performance during the construction phase, whereas the opposite is true supported with a positive coefficient of correlation (r=0.326) in the public construction industry Hussain, *et al*. 2020).

Several studies indicate the skilled craft shortage is not shortage of workers rather it is a shortage of adequately trained skilled and productive workers available for certain jobs (Olsen, Tatum & Defnall, 2012; Bilau et al., 2015). This shortage is attributed to the lack of training, an aging workforce, poor image of the workers, and an industry that does not appeal to many youth (Dainty, Ison & Root, 2004; Tarnoki, 2002). Thus it is found that most of the construction contractors choose to operate sometimes with teams that meet minimum requirement with regard to experience (Mushori, Rambo & Wafula, 2020).

Training is an organizational effort to change the behaviour or attitudes of employees so that they can perform to acceptable standards on the job (Awogbenle &Iwuamadi, 2010; Cheung, Chan & Kajewski, 2009). Dantong argued that training offers the platform for enhancing the potentials of the contractor craftsmen through the improvement on their skills and consequently contributes to contractors' performance in the construction industry (Dantong, 2007). Odesola and Idoro suggested that the most frequently used means of training or retraining are: job instruction training, conference or discussion, apprenticeship training, job rotation, coaching and lecture (Odesola & Idoro, 2014). In Indonesia, the professionalism and knowledge of skilled constructions worker are still low and that collaborative education and training can be used to improve skilled labour (Dardiri, *et al*., 2017). In a study by Leje, Shamsulhadi and Fadhli that used Kendall's coefficient of concordance to evaluate the level of agreement between construction organisations in relation to skilled workers, the results recorded revealed that glaziers, equipment operators, insulating specialist, fabricators, asphalt/tar sprayers, scaffolding specialist, plumbers, suspended ceiling specialist, roofers and electricians are the ten skilled trades needed by the construction organizations (Leje, Shamsulhadi & Fadhli, 2019). These skilled or technical trades are considered significant for the performance of construction firms. Thus, there is an imperative need to inaugurate skill certification centres that would serve as testing and certification centres for the skilled workers prior to being deployed into construction process (Okoro et al., 2020). Other previous findings show that the performance of low-skilled workers in construction industry

is significantly influenced by low wages, lack of incentives schemes for those skilled and insufficient skill acquisition centres (Zannah *et al*., 2017).

Potential Consequences of Failing to Address the Skills Shortage (Burns, 2023):

Delayed Infrastructure Projects **-** The shortage of skilled workers can significantly delay the completion of infrastructure and general construction projects. With insufficient workforce resources, projects may face extended timelines, leading to increased costs and disruptions in the overall development of critical infrastructure.

Increased Costs –

The demand for skilled workers outstrips supply, resulting in higher labour costs. This can inflate project budgets, making them financially unviable or requiring cuts in other essential areas.

Quality Compromises –

A lack of skilled workers can lead to compromised quality in construction projects. This can have long-term implications for the durability, functionality, and safety of the project, posing risks to public welfare.

Reduced Competitiveness –

A shortage of skilled workers can make the construction industry less competitive on a global scale. This can limit economic growth and hinder the development of a robust and sustainable construction sector.

2.2.3 Artificial Intelligence Adoption in Infrastructure Projects

AI was first presented in the 1950s with the goal of utilizing computer programs to mimic human intellect (Holzmann & Michele, 2022). The observation made by Trademark Africa is that a firm resistance to change to digital experiences and the many manual, repetitive tasks hobble the construction industry with project delays, cost inefficiencies, and undermined productivity, health, and safety performance (Trade Mark Africa, 2022).

Therefore, using artificial intelligence can be an important first step to addressing Africa's infrastructure gap by allowing policymakers to benefit from having better information at their disposal and making more informed decisions. In addition, AI's impact on improving workplace safety and productivity is likely to be several orders of magnitude larger than its potential impact on job losses. However, numerous challenges impede the advancement and efficient application of artificial intelligence in Africa. These barriers, which come from a variety of areas like infrastructure, education, legislation, and structural inequality, pose serious challenges to the continent's ability to properly utilize AI (Azaroual, 2024).

The realization of Artificial Intelligence (AI) benefits in Kenya strongly requires necessary skills among the workforces that can foster utilization of AI. Ndungi and Siregar (2023) define Artificial intelligence technology (AI) as an array of computer technologies that provide machines with human-like abilities in perception, action, and cognition. On April 8, 2024, Kenya marked a significant step towards integrating Artificial Intelligence (AI) into its future to drive sustainable growth. The Ministry of ICT and Digital Economy, in collaboration with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, launched the National AI Strategy Development Process (Gichohi, 2024).

AI can be used in the construction phase to assist with surveying, quality control, and equipment maintenance tasks (Mohapatra, Mohammed & Panda, 2023). For example, drones equipped with AI can survey construction sites and generate accurate 3D models, which can be used for progress tracking and identifying potential issues. Another area where AI can have a significant impact is in operation and maintenance of buildings. AI-powered building management systems can optimize energy usage, detect and diagnose equipment malfunctions, and predict maintenance needs. Overall, integrating AI into engineering and construction can improve project efficiency, reduce costs, and increase the safety and reliability of projects.

AI is considered a critical tool in planning, design, simulation of construction projects, and also used in advanced project execution phases of construction as well as in sourcing of materials and modularisation of high-end and specialised construction material and modules (Makaula, Munsamy & Telukdarie, 2021). Organisations are

advised to introduce learning tools and skills by changing the traditional work culture and promote AI adoption because of the value capabilities it brings in achieving efficiency, sustainability and productivity within the construction organisations and projects (Tjebane, Musonda & Okoro, 2022). Muthoni (2023) notes that the challenges of AI in Kenya are that AI practitioners lack an actionable framework to develop and deploy AI technology in alignment with data privacy and ethical safeguards and also limited awareness and understanding of AI. On studying the effects of artificial intelligence on Kenya society, Ndungi and Siregar (2023) found that most poor countries, particularly those in the sub-Saharan African region, do not have the necessary administration, learning, data reserves, and legislation to support the adoption and implementation of AI. They, however, noted that certain countries in sub-Saharan Africa, such as Kenya, have to some extent incorporated and used AI technologies in several key areas for the benefit of their inhabitants. They further conclude by stating that with the correct digital setting and facilities, data availability, education, and law, countries like Kenya in sub-Saharan Africa may adopt and apply AI.

In order to determine the crucial organizational elements that can accelerate the adoption of AI within the construction industry in Pakistan, Khan (2023) conducted a survey and performed an exploratory factor analysis (EFA) that revealed that a creative organizational culture, competence-based training, group decision-making, and strategic analysis are key factors for adopting AI. These remain key stumbling blocks in many of the African countries as observed by Ndungi and Siregar (2023). In view of Mugo (2019), the learning institutions should be at the forefront of championing for technology and ensuring graduates are at par with the rest of the world. A recent study by Egwim et al. (2024) on AI in the construction industry revealed that, in terms of the types of construction projects in which AI technologies were used, the majority of the scholarly articles included (58.60%) were related to built environment and residential building (28 articles in built environment and 13 articles in residential building). Following that were papers regarding high-rise and commercial buildings, which made for 18.60% of the articles chosen (7 articles in high-rise building and 6 articles in commercial building). Bridge/highway project and office building project were discovered in 7.10% and 4.30% of the total of 70 articles,

respectively. Moreover, power plant, timber construction, and architectural heritage projects all had the same number of articles (2 each), with only one article (1.40%) proposing the use of AI technology in retrofit building and water treatment plant. This is evident that AI in road construction infrastructure projects is yet to be fully adopted. At this juncture, we can conclude that there is need to carry out studies on AI adoption on construction projects in Sub-Saharan African region and particularly Kenya thus the need for this current study.

An investigation on the discrepancy of professional groups in Ethiopia on the perception of critical adoption strategies in public construction projects indicated that the top ranked building information modelling (BIM) adoption strategies are strategic and adequate Information Technology (IT) infrastructure, availability of standards and guidelines for BIM adoption, and government policy (Belay *et al*., 2023). Similarly, other six latent constructs developed from the factor analysis included organization, application and tools, market, information management, project, and process. Nasila and Cloete (2018) argued that while BIM was increasingly being applied worldwide to improve communication between project stakeholders, visualization of design, detect potential clashes, reduced redesign during project implementation, improve design quality, reduce costs, and improve the rate of return for projects, the application of BIM in the Kenyan construction industry was still lagging, resulting in poor co-ordination of information among construction project stakeholders.

3. METHODOLOGY

This study employed a descriptive survey research design and correlation research design. The design was to determine the status of the independent variables on the dependent variables (Gatotoh, Keiyoro & Gakuu, 2017). The study target population was 156 stratified as follows; 51 road contractors, 40 consulting engineers, 60 road authority engineers and 5 technical auditors working in road construction projects in Kenya. The road authority engineers were sampled from the following agencies: Kenya National Highway Authority (KeNHA), Kenya Urban Roads Authority (KURA) and Kenya Rural Roads Authority (KeRRA).

In this study, stratified sampling was applied for grouping the subjects into four strata, thereby using proportionate sampling to pick sample size from each stratum. Out of 156 a sample of 62 was obtained using proportionate random sampling representing 40%. According to Gay and Airasian a sample size between 10-40% is sufficient for analysis (Gay, & Airasian, 2001). The sampling techniques were applied so as to obtain a representative sample because the study population did not constitute a homogeneous group. The data was collected using self-administered questionnaires and interview guide. Using a simple random sampling, a total of 51 questionnaires were filled and returned representing 82.3% of the total number of questionnaire distributed having surpassed the Mugenda and Mugenda's pass mark of 70% exceptional (Mugenda, & Mugenda, 2009). Collected data was coded and entered into Statistical Packages for Social Scientists (SPSS) Version (21.0) and analyzed using descriptive statistics. The means and standard deviations, for central tendency and dispersion respectively, were presented as well as the interpretations thereof. Results were presented in Tables and Pie Chart. Pearson correlation analysis was performed to determine the relationship and strength of the predictor (skilled manpower) and the dependent variable (Contractor Performance) using coefficient of correlation (r). Simple linear regression was employed whereby Analysis of Variance (ANOVA) was performed to show how much of an independent variable (skilled manpower) account for the change in the dependent variable (Contractor performance) and for testing of the null hypothesis.

4. RESULTS AND DISCUSSIONS

The study results are presented in descriptive and inferential forms whereby the former is based on means and standard deviation whereas the latter is presented using correlation and regression.

4.1 Skilled manpower availability and contractor performance

The study sought to establish the extent to which availability of skilled manpower influence performance of contractors in road construction projects as shown in the Table 1.

Table 1. Skilled manpower and contractor performance

Statements	Mean	Std. Dev.
Availability of skilled manpower helps to expedite the achievement of project goals	4.71	0.46
Lack of skilled manpower delays or stalls altogether the performance	4.22	0.64
Skilled manpower provides quality performance of construction projects.	4.53	0.67
Skilled manpower saves wastefulness of resources during construction of roads	4.53	0.64
Shortage of manpower can affect performance	3.96	1.13
Lack of financial resources affects hiring skilled manpower	4.31	0.93
Cost of manpower development is beyond contractor's ability	3.59	0.98
Lack of appreciation to the role of manpower development	3.94	0.99
Contractors lack training program	3.80	0.92
Contractors experience high labour turnover	4.04	0.87
Low level of education affects skilled manpower	3.92	0.93

From the statements in Table 1, results imply that availability of skilled manpower would aid expediting achievement of project goals thus enhanced contractor contractors (Mean= 4.71), skilled labour leads to quality construction projects (Mean=4.53), skilled manpower plays a significant role in ensuring that resources are not wasted during road construction process (Mean=4.53). The respondents were in agreement that lack of skilled manpower can result to project delays and or can stall road construction projects (Mean=4.22). The study findings confirm that shortage of skilled manpower has adverse effect on the contractor performance (Mean=3.96). However, to be able to hire the right manpower, the contractor requires adequate financial resources (Mean=4.31). The results further indicate that most contractors in Kenya are experiencing high labour or manpower turnover which could be affecting their performance negatively (Mean=4.04). This can be explained by lack of contractor's appreciation to the role of manpower development (Mean=3.94). In addition, contractors lack a training program (Mean=3.80). The

respondents who took part in the survey confirmed that low level of education in the construction industry affects the contractor to have skilled manpower (Mean=3.92). On average, manpower development is beyond the contractors 'ability (Mean=3.59).

The study suggests that the availability of skilled manpower will hasten the attainment of project goals while the lack of the same will adversely affect project goal attainment. This is consistent with Bilau, *et al*. (2015) whose review examining the shortage of skilled craftsmen in the construction industry, particularly in small and medium construction firms in Nigeria revealed their significance in contractor performance. The findings of this study are also consistent with Thorat, *et al*. (2017) who found that the lack of skilled labour may cause delay of projects.

On skilled manpower the findings of this study agree with Bitamba and An (2020). The researchers' study established that the skills of the design team affect the design-related factors and hence the outcomes of the project. It is therefore, worth noting that the availability of skilled labour is paramount in contractor performance.

4.2.1 Level of AI adoption among the Infrastructure Experts

Various experts were asked to respond to a question on the level of AI adoption with respect to skills and knowledge acquisition and its utilization (Figure 2).

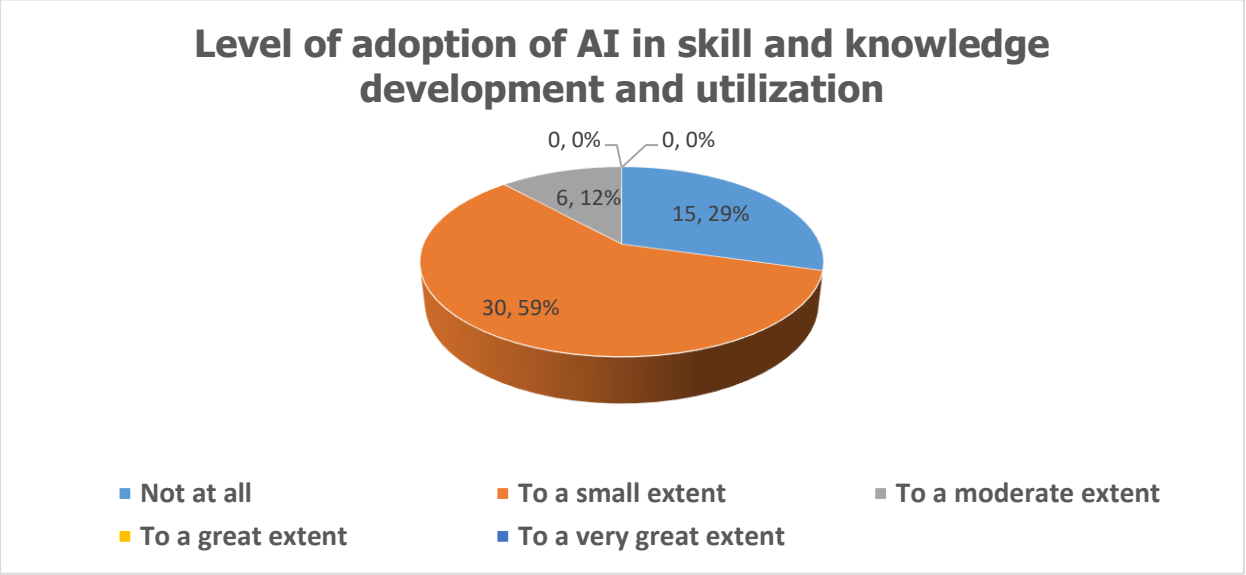

Figure 2. Level of AI adoption

According to the results in Figure 1, majority of the respondents 30(59%) indicate that skills and knowledge in AI have been acquired and utilization to a small extent. However, 6(12%) opine that AI is gradually being adopted among the construction infrastructural development projects. Whereas 15(29%) totally disagree that AI is not being utilized and neither the requisite skills needed to perform AI's tasks are presently acquired. These results rhyme with the findings of Roger's diffusion of Innovation theory that revealed that 13.5% are the early adopters of an innovation (Lamorte, 2019). The results are further supported by the summarized thematic results from the interviews with key informants:

Table 2. AI's Tools, Areas of Application, Challenges and Suggestions for the Way Forward

Some of AI's Tools Used in Kenya and Areas of Application	Market Challenges	Suggestion for the Way Forward
• **Nuclear gauge (Determine soil density)** • **Digital rebound hummer (Testing concrete strength)** • **Fellow Scan (Steel bar reinforcement)** • **Crack detector (Assess the type and causes of cracks)** • **Ultrasonic Pass Velocity Meter (Assess the quality of the concrete)** • **Chat GPT and and Quillbot (helps in explaining construction process e.g hydrological processes).** • **Drones (used in surveying and topographic mapping)** • **PTV Vissim (digitally used in reproducing the traffic**	• Engineering industry stuck to classical methods of analyses and AI tools not applicable to construction because of the diverse profession • AI software is costly with strict conditions • Low exposure among the construction experts (contractors and engineers, e.t.c) • Market operating with pirated/cracked copies of AI software that do not last long and miss out on all interface benefits. • AI policy is lacking	• Need to improve education/adopt a modern curriculum that encompass AI • AI is a win-win for both the client and workers thus need to create awareness and integrate it in the construction industry in Kenya • Consulting engineering firms and contractors should aim to have affordable workshop of modern tools • For commercial software to penetrate in the third world countries there is need for multinational companies developing AI to accord some subsides e.g 3 years grace period then begin to charge a reasonable fee • Engineers should adopt the drone technology to aid in site supervision. This can come in

patterns of all road users on a microscopic scale). • **Bump Integrator (BI) is a Class 3 response-type road roughness measuring equipment (used for roughness surveys on unpaved roads).** • **AI rendering (used in architectural designs).** • **Building Information Modeling (BIM) is a workflow process. (used for the planning, design, construction, and management of building and infrastructure projects.**	• Low adoption as a result of fear of loss of market	handy during poor weather conditions and in projects that cover larger geographical areas. • Government to design a policy AI

4.2 Inferential Analysis

This section presents results of the correlation and regression analysis of skilled manpower and contractor performance.

4.2.1Correlation Analysis

Correlation analysis was performed using Karl Pearson's Product Moment to establish the relationship between the variables (Table 3).

Table 3. Correlation Analysis

Variables		Skilled Manpower	Contractor Performance
SkilledManpower	Pearson Correlation	1	0.295*
	Sig. (2-tailed)		0.036
	n	51	51
Contractor Performance	Pearson Correlation	0.295*	1
	Sig. (2-tailed)	0.036	
	n	51	51

*. Correlation is significant at the 0.05 level (2-tailed).

The results in Table 2 show the relationship of skilled manpower (SM) and contractor performance (CP) to be significant although this correlation is a weak positive one, given that the coefficient of correlation (R) for SM is 0.295 and the p-values is 0.036(SM) less than 0.05 level of significance. This implies that the predictor (SM) has little influence on contractor performance. All the results are in line with Thorat, *et al.* (2015) and Bitamba and An (2020) who opine that contractor performance is influenced with skilled manpower and client management respectively, there is still need to enhance the skill set among the construction workers to ensure the current technology on AI is adopted and utilized within the construction industry. The findings also support Hussain *et al*. (2020) study that revealed that there exists a moderate strong positive linear and significant correlation between skilled labor and project performance positive (0.326) [22].

4.2.2Regression Analysis

Results of the simple linear regression are presented (Table 4) following a test of hypotheses of the study that were stated in both null (H_o) and alternate (H_1) forms as follows:

H_0: There is no relationship between skilled manpower and contractor performance.

H_1: There is a relationship between skilled manpower and contractor performance.

The regression equation used was as follows:

$Y= B_0 + B_1X_1 + \varepsilon$

Where Y = CP
X1 = Skilled Manpower (SM)
B0 = Constant term
B1 = Beta coefficients
ε = Error term

ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1.169	1	1.169	4.655	0.036[b]
	Residual	12.311	49	0.251		
Total		13.480	50			

Table 4: Regression Analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.295[a]	0.087	0.068	0.50124

Regression Coefficients						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	Std. Error	Beta		
1	(Constant)	1.377	0.231		5.953	0.000
	Skilled Manpower	0.225	0.104	0.295	2.158	0.036

Predictors: (constant), Skilled Manpower; Dependent Variable, Contractor Performance

From Table 4, the ANOVA was used to establish goodness of fit of the model. The calculated F (4.655) was greater than the critical value of F= 4.038 confirming that the model was fit. The coefficient of determination, R-Square of 0.087 implies that 8.7% of the variance in contractor performance is explained by skilled manpower. This implies that skilled manpower in Kenyan construction industry is still below average and that all the key players are required to work together to ensure all construction workers are equipped with the right and modern methods of implementing activities to ensure project success. The unstandardized beta (B) coefficient for SM was 0. 225. This implies that for a unit increase or 1% increase in skilled manpower, contractor performance increases by about 0.23%. This again still shows the need to improve the skills for workers undertaking construction activities. Thus, the regression equation to estimate the contractor performance (CP) earlier stated as: $Y= B_0+B_1X_1+\varepsilon$ was substituted as follows:

CP=1.377 + 0.225SM

The findings provide evidence that skilled manpower can greatly influence contractor performance. In this respect, we fail to accept the null (H_0) hypothesis and thus conclude in favour of alternate (H_1) hypothesis that, there is a relationship between skilled manpower and contractor performance. The study findings that skilled manpower is good predictor of contractor performance is in line with former studies conducted in the other countries (Bilau *et al*., 2015; Leje *et al*., 2019; Okoro *et al*., 2020; Zannah *et al.*, 2017). It is on this basis that we argue that skilled manpower within the construction industry should remain a mandatory requirement if projects have to completed successfully.

CONCLUSION

The study makes the following conclusions:

- That skilled manpower has a strong association with contractor performance.
- That availability of skilled manpower provides an impetuous for successful completion of road construction projects.
- That on job capacity building through training or retraining including job instruction training, conference or discussion, apprenticeship training, job rotation, coaching would be an important consideration in closing the gap in skilled manpower in the road construction sector.
- That lack of AI integration in the Kenyan market is as a result of factors of cost of buying and maintaining AI's software, lack of/inadequate curriculum on AI, lack of guiding policy on AI particularly in construction industry.
- The study contributes to AI skills development and infrastructure project management in Kenya by advocating for proper AI infrastructure and training. The country should move towards adoption of the current technology and cease utilizing the manual systems that hinder contractor performance and compromise industry's competitive advantage.

RECOMMENDATIONS

The following recommendations are informed by the study findings:

- In building and construction industry, Client in conjunction with the Consultants and Contractors should endeavor to work together to build the capacity of the hired team for successful project implementation. Where possible, on-site training should be offered so that quality products are delivered. Besides, such trainings would ensure minimum wastage of materials by the project team thus controlling costs.
- There is need for the construction Engineers to collaborate with government and draft a policy framework on the AI integration in construction processes.
- Ministry of education, colleges and universities stakeholders should develop a curriculum that help to train Kenyans on AI before joining the job market. This will be a major contributor to skills and knowledge development required in construction industry. This will play a pivotal role in enhancing performance or infrastructure of projects in terms of quality of final products.
- There is need to reemphasize the importance of public awareness and knowledge-sharing as far AI is concerned among the Kenyan professionals in building and construction industry.

- Drone technology should be used by engineers to help with site oversight. This can be useful for projects that span wider geographic areas and in inclement weather.
- Multinational corporations creating AI must provide some subsidies, such as a three-year grace period before starting to charge a fair price, in order for commercial software to become widely used in third-world nations.

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