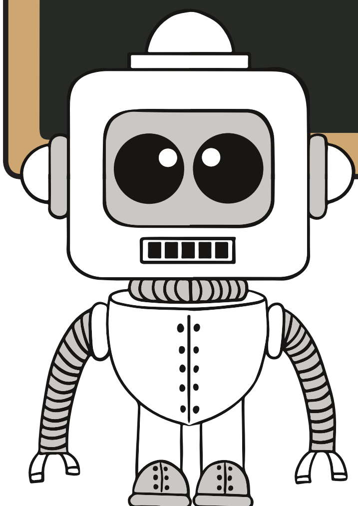
AI IN EDUCATION: THE ETHICAL IMPACT OF INTELLIGENT TUTORING SYSTEMS IN KENYA'S PRIMARY SCHOOLS

A report assessing the ethical implications of AI-driven tutoring in Kenya's primary level education system.



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Executive Summary

This report assesses the implications of AI-driven tutoring in Kenya's primary level education system, by examining the implementation and impact of Intelligent Tutoring Systems (ITS) in the Kenyan education sector. It highlights the current state of ITS in Kenya, the barriers to their effective use, benefits, and the necessary policy frameworks to support their integration.

The findings indicate that ITS can significantly enhance educational outcomes by improving accessibility, personalising learning experiences, and optimising resource allocation. However, the successful implementation of these systems is hindered by several key challenges, including the digital divide, inadequate infrastructure, insufficient teacher training, and the need for culturally relevant content. The report emphasises the importance of addressing these issues to ensure equitable access to ITS, particularly in rural areas.

Finally, the report advocates for increased investment in rural infrastructure, partnerships with telecommunications providers for improved connectivity, and the provision of affordable devices. It also stresses the need for comprehensive teacher training and the development of culturally relevant educational content, to improve the ongoing use of ITS, ultimately leading to improved educational outcomes in Kenya.

1. Introduction

Intelligent Tutoring Systems (ITS) are computer-based educational platforms designed to enhance the learning experience by providing tailored instruction catering to each student's needs.[1] These systems utilise Artificial Intelligence (AI) to assess learner performance, identify errors, and deliver immediate feedback, replicating the benefits of one-on-one tutoring.[2] The platforms offer learning mechanisms such as standardised tests, homework issuance and marking, and simulations embedded to illustrate concepts to learners.[3] As such, ITS programs are designed to adequately assess learner needs and design materials based on this assessment.

Integrating AI in education presents potential benefits for learners and instructors, particularly in regions facing significant education access gaps. For instance, Kenyan public schools face dire teacher shortages, with a student-to-teacher ratio as high as 70:1 in some schools, which prevents teachers from successfully paying attention to each learner's unique needs.[4] This is despite the fact that the recommended ratios are 1:35 for secondary schools, 1:40 for primary schools, and 25:1 for pre-primary learners.[5] In line with the new competency-based curriculum, digital literacy is a key focus area as educators prepare learners for the demands of the digital world.[6] Further, integration of AI in learning would mitigate the negative impact of an influx of students in most public schools, which causes students inability to access one-on-one attention from their teachers.[7] Thus, the growing use of ITS in both primary and secondary schools is evident, as stakeholders attempt to personalise students' experiences and improve their performance.[8]

Among the ITS deployed in Kenya is MwalimuPlus, which provides learning support for primary-school learners while maintaining a human-centred education philosophy.[9] One benefit of this system is that it maps learner differences and maintains a performance record allowing each student to learn at their pace and teachers to make decisions based on this data.[10] Thus, as African technology access increases, integrating AI and other technologies in the learning environment has the potential to supplement overburdened educational personnel, and enhance their ability to meet learner needs.

Despite its benefits, the integration of ITS in education presents ethical concerns. It is therefore crucial to pay attention to ethical, regulatory and policy considerations when deploying ITS in learning environments to ensure responsible use of technology and to protect human rights.[11] It is necessary to address and mitigate data privacy

[1] Chien-Chang Lin, Anna YQ Huang and Owen HT Lu, 'Artificial Intelligence in Intelligent Tutoring Systems toward Sustainable Education: A Systematic Review' (2023) 10 Smart Learning Environments <https://slejournal.springeropen.com/articles/10.1186/s40561-023-00260-y> accessed 12 August 2024.

[2] Potter Kaledio, Abill Robert and Louis Frank, 'The Impact of Artificial Intelligence on Students' Learning Experience' [2024] Social Science Research Network <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4716747> accessed 12 August 2024.

[3] Anderson Pinheiro Cavalcanti and others, 'Automatic Feedback in Online Learning Environments: A Systematic Literature Review' (2021) 2 Computers and Education: Artificial Intelligence 100027 <https://www.sciencedirect.com/science/article/pii/S2666920X21000217> accessed 12 August 2024.

[4] Peter Barasa, 'Background Report Digitalization in Teaching and Education in Kenya Digitalization, the Future of Work and the Teaching Profession Project' (2021) <https://www.ilo.org/media/386411/download#:~:text=3%20Some%20national%20schools%20register> accessed 12 August 2024.

[5] 'Basic Education Statistical Booklet' (2020) <https://www.education.go.ke/sites/default/files/Docs/The%20Basic%20Education%20Statistical%20Booklet%202020%20(1).pdf> accessed 12 August 2024.

[6] Maxwell Fundi and others, 'Advancing AI Education: Assessing Kenyan In-Service Teachers' Preparedness for Integrating Artificial Intelligence in Competence-Based Curriculum' (2024) 14 Computers in human behavior reports 100412 <https://www.sciencedirect.com/science/article/pii/S2451958824000459> accessed 12 August 2024.

[7] Ratemo Cyprian, 'Integration of Mobile Intelligent Tutoring Systems in Teaching Mathematics' (IRJET 2020) <https://www.irjet.net/archives/V7/i7/IRJET-V7I7930.pdf> accessed 12 August 2024.

[8] Ratemo Cyprian, 'Integration of Mobile Intelligent Tutoring Systems in Teaching Mathematics' (IRJET 2020) <https://www.irjet.net/archives/V7/i7/IRJET-V7I7930.pdf> accessed 12 August 2024.

[9] MwalimuPlus, 'A Custom-Made Intelligent Tutoring System for Kenyan Students and Teachers' (2018) <https://www.mwalimuplus.com/data/uploads/WhitePaper.pdf> accessed 12 August 2024.

[10] ' A Custom-Made Intelligent Tutoring System for Kenyan Students and Teachers' (2018) <https://www.mwalimuplus.com/data/uploads/WhitePaper.pdf> accessed 12 August 2024.

[11] Chien-Chang Lin, Anna YQ Huang and Owen HT Lu, 'Artificial Intelligence in Intelligent Tutoring Systems toward Sustainable Education: A Systematic Review'

and security, bias, digital divide, and accountability concerns. ITS collect extensive data about users, most of whom are children, to create profiles and establish learning mechanisms.[12] The systems are open for access by instructors, parents and other stakeholders, presenting risks of data misuse and learner perceptions based on the data.[13] Additionally, algorithmic bias is a major concern, where ITS can make prejudiced decisions based on biased training data.[14] Finally, the digital divide witnessed in Kenya presents concerns that students with internet and computer access benefit over others without access to these resources.[15] Thus, there is a need to identify the available regulatory protections needed to mitigate privacy, algorithmic bias and digital divide risks presented by deployment of ITS in Kenya.

This study examines the use of ITS in Kenya based on a systematic literature review, centred on a case study of adopted ITS, challenges of adoption, the relevant policy environment, and policy recommendations for future directions.

2. Purpose and Importance of the Study

The continued implementation of ITS in Kenyan schools presents a unique opportunity to address the multifaceted challenges faced by the education sector. This continued integration necessitates an examination of the impact of using ITS in education, particularly with regard to the major policy concerns that arise, such as privacy considerations, algorithmic bias and the existing digital divide.

The findings of this study will be beneficial to the integration of ITS in education, as it will inform teachers, parents, learners and policy stakeholders on the impact and challenges of ITS adoption. It will also provide an overview of the policy environment, while identifying regulatory gaps to offer recommendations on future actions to ensure effective adoption.

Finally, this study is important for regulators such as the Office of the Data Protection Commissioner (ODPC), as they issue sector specific regulations on data protection in this context, to ensure that they provide contextualised guidance on compliance.

3. Methodology of the Study

The study employs desk research through a comprehensive literature review of prior work on ITS. It surveys relevant books, journals, websites, blog posts, and reports to understand the extent of application of ITS in Kenyan education, its impact, challenges of adoption, and the relevant regulatory frameworks for ITS use. By identifying the challenges, opportunities and existing regulatory framework, the study provides recommendations.

4. Scope and Limitations of the Study

The primary focus of the study is Kenya, specifically examining the ways in which innovative educators in the country implement ITS. Simultaneously, several ITS utilised by Kenyan students are accessible to a broader audience in Eastern or Sub-Saharan Africa. However, the policy and regulatory frameworks examined are Kenyan, with a view to inform Kenyan ITS stakeholders such as service providers, regulators, policy researchers, teachers, parents and learners.

Regarding limitations, this study faced significant challenges when examining the specific impacts of ITS in Kenyan education. One such difficulty was finding relevant information about the ITS that are now in use in Kenya. Instead of primary data from users, the information that was accessible was primarily anecdotal and secondary data. The research process was further complicated by the absence

[12] Rachel Achieng' Odhiambo, Emmah Wakoli and Michelle Rodrot, 'Data Privacy in Africa's Ed-Tech Platforms: Children's Right to Privacy' (2021) <https://cipit.strathmore.edu/wp-content/uploads/2023/02/EdTech-Brief-Final.pdf> accessed 12 August 2024.
[13] Rachel Achieng' Odhiambo, Emmah Wakoli and Michelle Rodrot, 'Data Privacy in Africa's Ed-Tech Platforms: Children's Right to Privacy'
[14] Ryan S Baker and Aaron Hawn, 'Algorithmic Bias in Education' (2021) 32 International Journal of Artificial Intelligence in Education <10.1007/s40593-021-00285-9> accessed 12 August 2024.
[15] Doreen Abiero and Dan Allan Kipkoech, 'Kenya's Digital Deserts - Centre for Intellectual Property and Information Technology Law' (Centre for Intellectual Property and Information Technology Law (CIPIT)27 September 2023) <https://cipit.strathmore.edu/kenyas-digital-deserts/> accessed 12 August 2024.

of algorithmic openness, since it is challenging to analyse the algorithms and the data that result from them in order to ascertain the impact of ITS use in education that can be statistically verified.

Despite these challenges, the researchers successfully identified the key trends regarding the current application of ITS in Kenyan education, highlighting their impact, adoption challenges, policy considerations, and recommendations.

5. Intelligent Tutoring Systems Use In Kenya

5.1 Introduction to ITS

ITS refer to computer-based educational systems designed to increase the learning rate and retention of content by learners by using AI to provide learners with instructions.[16] ITS are personalised educational systems that integrate computer learning with AI techniques to deliver adaptive guidance and instruction, evaluate learners, and classify or cluster learners.[17] An effective ITS program should be able to adequately assess learner errors and design remediation based on the assessment of the learner.[18] An effective intelligent tutoring system includes an improved knowledge base, adaptive presentation, and personalised learning with an adaptive algorithm.[19] This capability is especially crucial in regions with teacher shortages or large class sizes, such as Kenya, where ITS can significantly enhance educational outcomes.

The development of ITS dates back to the 1970s and 1980s, marking the early stages of integrating AI into educational contexts. One of the pioneering systems, SCHOLAR, developed by Jaime Carbonell in 1970, utilised an AI approach to computer-assisted instruction, setting the stage for future ITS advancements.[20] These early systems primarily focused on providing adaptive instructional content and personalised feedback, aiming to emulate the one-on-one tutoring experience through computer-based platforms.[21] As the field progressed, the 1990s saw significant developments with systems like the Cognitive Tutor, developed by John Anderson and his colleagues.[22] This system was grounded in cognitive psychology and aimed to model student thinking processes to provide tailored instructional support.[23] The Cognitive Tutor's success in improving student learning outcomes underscored the potential of ITS and spurred further research and development in this area.[24]

5.2 Current Global Trends in ITS

Today, ITS have evolved to incorporate advanced AI techniques, making them more sophisticated and effective. Modern systems such as ALEKS (Assessment and LEarning in Knowledge Spaces), Knewton, and Carnegie Learning leverage machine learning algorithms to continually assess and adapt to student performance, offering a highly personalised learning experience.[25] ALEKS, for instance, uses an adaptive questioning system to accurately determine a student's knowledge state and provides customised

[16] Mingqian Chen. "A comparison of machine learning techniques in building an intelligent tutoring system." Applied and Computational Engineering (2023). https://doi.org/10.54254/2755-2721/5/20230673> accessed 5 August 2024.

[17] Elham Mousavinasab, Nahid Zarifsanaiey, S. R. N. Kalhori, M. Rakhshan, L. Keikha and M. Saeedi. "Intelligent tutoring systems: a systematic review of characteristics, applications, and evaluation methods." Interactive Learning Environments, 29 (2018): 142 - 163. https://doi.org/10.1080/10494820.2018.1558257 . accessed 5 August 2024.

[18] Shute, V. J., & Psotka, J. (1994). 'Intelligent tutoring systems: Past, present, and future.' Human Resources Directorate, Manpower and Personnel Research Division, Brooks Air Force Base,TX. https://myweb.fsu.edu/vshute/pdf/shute%201996_d.pdf accessed 5 August 2024.

[19] Jirapond Muangprathub, V. Boonjing and K. Chamnongthai. "Learning recommendation with formal concept analysis for intelligent tutoring system." Heliyon, 6 (2020). https://doi.org/10.1016/j.heliyon.2020.e05227 . accessed 5 August 2024.

20Doroudi, S. 'The Intertwined Histories of Artificial Intelligence and Education.' Int J Artif Intell Educ 33, 885–928 (2023). https://doi.org/10.1007/s40593-022-00313-2 accessed 5 August 2024.

[21] ibid

22Shute, V. J., & Psotka, J. (1994). 'Intelligent tutoring systems: Past, present, and future.' Human Resources Directorate, Manpower and Personnel Research Division, Brooks Air Force Base,TX. https://myweb.fsu.edu/vshute/pdf/shute%201996_d.pdf accessed 5 August 2024.

[23] John R. Anderson, Albert T. Corbett, Kenneth R. Koedinger, and Ray Pelletier, 'Cognitive Tutors: Lessons Learned,' https://apps.dtic.mil/sti/tr/pdf/ADA312246.pdf accessed 5 August 2024.

[24] ibid.

[25] Redress Compliance, 'AI for STEM Education and Student Success,' https://redresscompliance.com/ai-stem-education/ accessed 5 August 2024.

ITS are personalised educational systems that integrate computer learning with AI techniques to deliver adaptive guidance and instruction, evaluate learners, and classify or cluster learners.

learning paths accordingly.[26] Similarly, Knewton and Carnegie Learning employ data-driven approaches to enhance student engagement and improve learning outcomes.[27]

The effectiveness of ALEKS was shown in a study that involved 100 students from five high schools in the United States, who were divided into two groups: the ALEKS Group, which completed the ALEKS Pre-Calculus Learning Modules, and the Non-ALEKS Group, which did not complete the modules.[28] The ALEKS Group had a total of 73 participants, while the Non-ALEKS Group had 27 participants.[29] The ALEKS Group participants showed greater increases in performance on the ALEKS College Mathematics Placement Exam compared to the Non-ALEKS Group.[30] In the ALEKS Group, the October exam scores ranged from 3 to 60, with a mean score of 30.425, and the May exam scores ranged from 3 to 84, with a mean score of 43.973.[31] On the other hand, the Non-ALEKS Group had October exam scores ranging from 0 to 61, with a mean score of 21.482, and May exam scores ranging from 1 to 54, with a mean score of 20.556.[32] These statistics provide a detailed comparison of the exam scores for both groups, including the number of students, minimum and maximum scores, mean scores, and standard deviations for both the October and May exams.

5.3 Effectiveness of ITS vs. Traditional Tutoring

Incorporating machine learning and natural language

[26]Eric Cosyn, Hasan Uzun, Christopher Doble, Jeffrey Matayoshi, 'A practical perspective on knowledge space theory: ALEKS and its data,' Journal of Mathematical Psychology, Volume 101, 2021, 102512, ISSN 0022-2496, https://doi.org/10.1016/j.jmp.2021.102512. accessed 7 August 2024.
[27] Owan, Valentine Joseph, Kinsgley Bekom Abang, Delight Omoji Idika, Eugene Onor Etta, and Bassey Asuquo Bassey. 'Exploring the potential of artificial intelligence tools in educational measurement and assessment.' Eurasia Journal of Mathematics, Science and Technology Education 2023 19 no. 8 (2023): em2307. https://doi.org/10.29333/ejmste/13428 accessed 7 August 2024.
[28]Jenny Nehring, Patricia Moyer-Packenham, Matt North, 'Assessing the effectiveness of an artificial intelligence tutoring system for improving college-level mathematics preparedness in high school students,' Issues in Information Systems Volume 24, Issue 1, pp. 128-141, 2023 https://doi.org/10.48009/1_iis_2023_111 accessed 12 August 2024.
[29]ibid
[30] ibid
[31] ibid
[32]bid

processing has further enhanced ITS capabilities by enabling more accurate assessments of student needs and more nuanced feedback.[33] A significant body of research, including a comprehensive review by Kurt VanLehn, highlights the relative effectiveness of ITS compared to traditional tutoring methods, underscoring their potential to revolutionise education.[34]

ITS represent a groundbreaking advancement in the educational field, offering students personalised and adaptive learning experiences that have the potential to transform traditional instructional methods. This review looks into the effectiveness of ITS compared to conventional tutoring approaches, drawing on a wide range of research findings.

5.3.1 Learning Outcomes and Achievement

ITS have consistently demonstrated a significant positive impact on learning outcomes across various educational levels and subject areas. A comprehensive meta-analysis revealed that ITS outperform traditional teacher-led instruction, large-group sessions, and non-ITS computer-based learning tools.[35] Specifically, ITS showed effect sizes of 0.42, 0.57, and 0.35, respectively, when compared to these traditional methods.[36] In one study focusing on K-12 students' reading comprehension, ITS produced a notable effect size of 0.86, surpassing the effectiveness of traditional teaching methods.[37] Moreover, ITS have shown moderate positive effects on college students' academic performance, outperforming both traditional classroom instruction and other educational activities.[38]

5.3.2 Comparison with Human Tutoring

While ITS have proven to be highly effective, they are still slightly less effective than human tutoring. The meta-analysis indicated no significant difference between ITS and individualised human tutoring, with an effect size difference of just -0.11, and a minimal difference of 0.05 when compared to small-group instruction.[39] In the realm of reading comprehension, ITS produced a modest effect size of 0.20 when compared to human tutors, highlighting that while ITS are beneficial, they may not yet fully replace the nuanced guidance of human educators.[40]

5.3.3 Personalisation and Adaptability

Traditional education systems often face challenges in addressing the diverse learning styles and varying levels of student preparedness, leading to frustration and unmet educational needs.[41] In contrast, ITS excel in offering personalised instruction tailored to each student's unique needs, significantly enhancing learning efficiency and satisfaction.[42] The adaptability of ITS allows them to cater to individual learning paces, ensuring that all students, regardless of their starting point, can achieve their full potential.

[33] E. Kochmar, Dung D. Vu, Robert Belfer, Varun Gupta, Iulian Serban and Joelle Pineau. 'Automated Data-Driven Generation of Personalized Pedagogical Interventions in Intelligent Tutoring Systems.' International Journal of Artificial Intelligence in Education, 32 (2021): 323 - 349. https://doi.org/10.1007/s40593-021-00267-x. accessed 7 August 2024.

[34] Kurt VanLehn. 'The Relative Effectiveness of Human Tutoring, Intelligent Tutoring Systems, and Other Tutoring Systems.' Educational Psychologist, 46 (2011): 197 - 221. https://doi.org/10.1080/00461520.2011.611369. accessed 7 August 2024.

[35] Wenting Ma, Olusola O. Adesope, J. Nesbit and Qing Liu. "Intelligent tutoring systems and learning outcomes: A meta-analysis." Journal of Educational Psychology, 106 (2014): 901-918. https://doi.org/10.1037/A0037123. accessed 22 August 2024.

[36] ibid

[37] Zhihong Xu, K. Wijekumar, Gilbert Ramirez, Xueyan Hu and Robin Irey. "The effectiveness of intelligent tutoring systems on K-12 students' reading comprehension: A meta-analysis." Br. J. Educ. Technol., 50 (2019): 3119-3137. https://doi.org/10.1111/BJET.12758. accessed 22 August 2024.

[38] Saiying Steenbergen-Hu and H. Cooper. "A meta-analysis of the effectiveness of intelligent tutoring systems on college students' academic learning." Journal of Educational Psychology, 106 (2014): 331-347. https://doi.org/10.1037/A0034752. accessed 22 August 2024.

[39] Wenting Ma, Olusola O. Adesope, J. Nesbit and Qing Liu. "Intelligent tutoring systems and learning outcomes: A meta-analysis." Journal of Educational Psychology, 106 (2014): 901-918. https://doi.org/10.1037/A0037123. accessed 22 August 2024.

[40] Zhihong Xu, K. Wijekumar, Gilbert Ramirez, Xueyan Hu and Robin Irey. "The effectiveness of intelligent tutoring systems on K-12 students' reading comprehension: A meta-analysis." Br. J. Educ. Technol., 50 (2019): 3119-3137. https://doi.org/10.1111/BJET.12758. accessed 22 August 2024.

[41] Asst. Lecturer. Talib Qasim Ali Al-aqbi, Asst. Lecturer. Ahmed Yousif Falih, Asst. Lecturer. Basma Jumaa Saleh, Eng. Nadia Muwafaq Al-juaifari and Eng. Lamees Abdulhassan. "The Effect of the Intelligent Tutoring Systems on the Education." مجلة أبحاث الذكاء (2019). https://doi.org/10.36302/jir.v0i27.32. accessed 22 August 2024.

[42] Luqman M Rababah. "The Impact of an Intelligent Tutoring System (ITS) on the Academic Progress and Success of EFL Jordanian Students: A Quasi-Experimental Study." International Journal of Emerging Technologies in Learning (iJET) (2023). https://doi.org/10.3991/ijet.v18i16.41471. accessed 22 August 2024.

5.3.4 Cost and Development

The development of traditional ITS, which involves intricate student diagnosis and adaptive instructional techniques, can be costly.[43] However, non-diagnostic ITS, which focus on modelling expert reasoning and promoting collaborative learning, present a more cost-effective alternative while still delivering substantial educational benefits.[44] These systems provide a practical solution for scaling personalised learning experiences across various educational settings.

5.3.5 Subject-Specific Effectiveness

ITS have shown particular effectiveness in STEM subjects at the university level, where they help students apply theoretical knowledge to solve complex problems through interactive dialog systems.[45] In mathematics, for instance, ITS have demonstrated a small but positive effect on kindergarten to 12th grade (K-12) students' learning, with shorter interventions and use among the general student population proving more effective.[46]

5.3.6 Student Satisfaction and Engagement

Students who use ITS report higher levels of satisfaction compared to those in traditional classroom environments. A case study involving English as a Foreign Language (EFL) students in Jordan revealed significant improvements in grammar, vocabulary, and reading comprehension when ITS were used, alongside increased student satisfaction.[47] This indicates that ITS not only enhance academic performance but also positively impact students' overall learning experiences.

The evidence strongly supports the effectiveness of ITS as tools for enhancing student learning. Although ITS have not yet fully surpassed the effectiveness of human tutoring, they offer a scalable and personalised learning experience that addresses the diverse needs of students. The integration of ITS into educational settings holds great promise for improving learning outcomes, student satisfaction, and the overall efficiency of education.

5.4 The State of Education in Kenya

Kenya's educational landscape presents unique challenges and opportunities for the adoption of ITS. The country's education system has historically faced issues such as large class sizes, limited resources, and disparities in educational access.[48] Despite these challenges, there has been a growing emphasis on integrating technology into education to bridge these gaps. Initiatives like the Digital Literacy Programme aim to equip students and teachers with digital skills, laying the groundwork for the adoption of advanced educational technologies .

5.4.1 Case Studies of ITS in Kenyan Schools

In Kenya, AI is increasingly being utilised in the education sector, with several notable applications. One example is Angaza Elimu, an eLearning platform that uses AI to deliver personalised learning experiences tailored to each student's needs.[49] This platform provides students with access to learning materials and assignments customised to their unique learning styles and allows them to track their progress.[50] Additionally, it enables tutors to assess students' capabilities and offer tailored learning resources. Angaza Elimu, through its initiative Kalamu, aims to integrate Intelligent Tutoring Systems (ITS) into the competency-based curriculum at an affordable rate that starts from 10

[43] L. Gugerty. "Non-diagnostic intelligent tutoring systems: Teaching without student models." Instructional Science, 25 (1997): 409-432. https://doi.org/10.1023/A:1003089914104. accessed 22 August 2024.
[44] ibid
[45] José Paladines and J. Ramírez. "A Systematic Literature Review of Intelligent Tutoring Systems With Dialogue in Natural Language." IEEE Access, 8 (2020): 164246-164267. https://doi.org/10.1109/ACCESS.2020.3021383. accessed 22 August 2024.
[46] Saiying Steenbergen-Hu and H. Cooper. "A meta-analysis of the effectiveness of intelligent tutoring systems on K–12 students' mathematical learning.." Journal of Educational Psychology, 105 (2013): 970-987. https://doi.org/10.1037/A0032447. accessed 22 August 2024.
[47] Luqman M Rababah. "The Impact of an Intelligent Tutoring System (ITS) on the Academic Progress and Success of EFL Jordanian Students: A Quasi-Experimental Study." International Journal of Emerging Technologies in Learning (iJET) (2023). https://doi.org/10.3991/ijet.v18i16.41471. accessed 22 August 2024.
[48] Limo J. Beatrice and Erastus Muchimuti. "Inequitable Access to Quality Education in Primary and Secondary Schools in Kenya." East African Scholars Journal of Education, Humanities and Literature (2022). https://doi.org/10.36349/easjehl.2022.v05i01.003 . accessed 12 August 2024.
[49] *Angaza Elimu https://angazaelimu.com/about accessed 7 August 2024.*
[50] ibid

Kenya Shillings[51] by focusing on three key areas: adaptive learning, which intelligently adjusts content and pacing to enhance student understanding; personalised learning, which offers tailored and customised learning experiences to boost student engagement; and teacher intervention, which provides actionable insights to support targeted interventions by educators.[52]

Another application is M-Shule, an SMS-based platform that facilitates the delivery of learning, evaluation, and data tools to organisations.[53] M-Shule's personalised tuition tool has enabled primary school students across East Africa to improve their exam scores by 7%-20% through SMS-based learning in English, Kiswahili, and Math. The platform also pioneered storytelling through SMS, adapting African stories into an interactive format accessible on basic feature phones, further enhancing student engagement and learning outcomes.

Kenya's education system also uses iMlango which delivers access to digital education services and content, especially to hard-to-reach learners in rural areas.[54] iMlango supports 180,000 pupils, including 70,000 marginalised girls, in 240 schools across four counties—Kajiado, Kilifi, Makueni, and Uasin Gishu. These schools, situated in rural or semi-urban areas, were selected based on various criteria of marginalisation, such as poverty rates, attendance levels, and the availability of educational opportunities for girls.[55] In these communities, in-field teams engage uniquely with parents, schools, and the wider community to foster a supportive educational environment.

MwalimuPlus is also another ITS that seamlessly integrates with the Kenyan curriculum, offering a flexible and adaptive learning environment.[56] By combining pedagogy and technology, it allows teachers to effortlessly incorporate it into the

[51]Kalamu, 'https://kalamu.net/,' accessed 8 August 2024.
[52]Angaza Elimu, 'https://angazaelimu.com/' accessed 8 August 2024.
[53]M-shule https://m-shule.com/ accessed 7 August 2024.
[54]iMlango,https://www.imlango.com/ accessed 7 August 2024.
[55]iMlango, 'https://www.imlango.com/our-story,' accessed 8 August 2024.
[56]MwalimuPLUS, 'A Custom-made Intelligent Tutoring System for Kenyan Students and Teachers,' https://www.mwalimuplus.com/data/uploads/WhitePaper.pdf accessed 7 August 2024.

teaching-learning process. MwalimuPlus enhances student engagement by providing individualised feedback and creating an adaptive learning experience. As a cost-effective and efficient solution, it supports both teachers and students in achieving better educational outcomes in Kenya.

However, the adoption of AI in Kenyan education is not without its hurdles. Challenges such as limited internet access, insufficient training for teachers, and the need for localised content must be addressed to fully realise the benefits of ITS. Despite these obstacles, the positive outcomes from initial implementations provide a strong case for expanding the use of AI in education across the country. To this end, the Ministry of Education established Digischool to provide interactive, relevant digital content based on a competency-based curriculum.[57] The Digischool website offers a breakdown of schools by county, including details such as the total number of schools, those with installations pending, the percentage already installed, as well as the number of learner devices, teacher devices, routers, and projectors.[58]

Moreover, Kenya also has digital literacy policies focusing on providing education and training to improve individuals' digital skills. Addressing the digital literacy gap in Kenya is crucial since many individuals lack the proficiency needed to navigate digital technologies effectively. For instance, the Ministry of ICT and the Digital Economy embraced initiatives like the Digital Skills Programme.[59] This initiative plays a significant role in enhancing digital literacy by providing targeted training and education, as evidenced by over 80,000 public primary school teachers being trained in readiness for a technology-inspired approach to learning.[60] The Kenyan government has these programs, which not only bolster basic digital competencies

[57]Digischool, 'https://www.digischool.go.ke/' accessed 7 August 2024.
[58]DLP County Summary, https://www.digischool.go.ke/dlp_summary/county_summary accessed 7 August 2024..
[59]Ministry of Information, Communication and Technology and the Digital Economy Economy, 'Digital Literacy Programme(DLP)' https://ict.go.ke/digital-literacy-programmedlp/ accessed 7 August 2024.
[60]e-Governance Academy, 'Kenya Digital Readiness Study, https://ega.ee/wp-content/uploads/2022/07/Kenya-Digital-Readiness-Study.pdf accessed 7 August 2024.

By acquiring these skills, individuals can better protect their personal data and engage with digital tools responsibly, mitigating potential risks associated with online activities.

but also emphasise information literacy and data protection.[61] By acquiring these skills, individuals can better protect their personal data and engage with digital tools responsibly, mitigating potential risks associated with online activities.

5.4.2 Impact of ITS use in Education in Kenya

The study conducted by Maxwell Fundi, Ismaila Temitayo Sanusi, Solomon Sunday Oyelere, Mildred Ayere exploring the readiness of Kenyan in-service teachers to incorporate AI into their teaching practices is crucial in assessing the potential impact of ITS integration in the Kenyan education system.[62] It begins by emphasising the growing significance of AI in education and the necessity for educators to adapt to technological advancements. Grounded in the Theory of Planned Behavior (TPB), which suggests that subjective norms, alongside other factors, significantly influence individuals' intentions and behaviour, the study argues that favourable subjective norms within the educational community can enhance teachers' preparedness to teach AI.[63]

The research employed a quantitative methodology, surveying 308 in-service teachers from various counties in Kenya.[64] It aimed to assess teachers' confidence in AI, their attitudes towards it, their understanding of AI ethics, and the perceived threats associated with AI technologies. The findings revealed that while teachers generally exhibited moderate confidence in AI and positive attitudes towards its integration into the curriculum, there was variability in their understanding of AI ethics and the subjective norms influencing their readiness to teach AI.[65] Key determinants such as confidence, ethical considerations, and subjective norms were identified as critical factors shaping teachers' preparedness for AI education.[66]

The study highlights the importance of professional development programs to boost teachers' confidence in AI and address ethical concerns related to its use in education. It advocates for a collaborative approach to AI integration, involving various educational stakeholders, including peers and administrators,

[61] ibid.

[62] Maxwell Fundi, Ismaila Temitayo Sanusi, Solomon Sunday Oyelere, Mildred Ayere, 'Advancing AI education: Assessing Kenyan in-service teachers' preparedness for integrating artificial intelligence in competence-based curriculum,' Computers in Human Behavior Reports, Volume 14, 2024, 100412, ISSN 2451-9588, https://doi.org/10.1016/j.chbr.2024.100412. accessed 8 August 2024.

[63] ibid

[64] ibid

[65] ibid

[66] ibid

to foster a supportive environment for teachers.[67] The authors suggest that future research should include perspectives from other stakeholders, such as students and parents, to gain a comprehensive understanding of AI implementation in schools.[68] Additionally, they recommend the development of AI intervention programs and hands-on workshops tailored for educators to facilitate effective AI teaching.[69]

The study underscores the need for targeted initiatives to prepare teachers for the challenges and opportunities presented by AI in education. By addressing the identified factors influencing teachers' readiness, the research provides valuable insights for policymakers and educational leaders aiming to enhance AI education in Kenya. The findings contribute to the broader discourse on integrating technology into the curriculum, emphasising the critical role of teacher preparedness in shaping the future of education in an increasingly digital world.

6. Ethical Consideration of Intelligent Tutoring Systems

Whenever AI is discussed, ethics is usually a central point of discussion, and this centrality is no better shown than the attention AI ethics has received from the growing scholarship on AI.[70] It has been suggested that the significance of ethics has only increased in tandem with the rapid advancement of AI technologies.[71] ITS and their use in Kenya are no exception and, therefore, they are subject to this complex interplay between AI and ethics.

One might venture to question whether the ethics that arises in discussion in this context is the broad notion that ethics intrinsically carries,[72] or whether it is guided by certain precepts. Fortunately, various organisations have developed ethical guidelines and principles for the deployment of AI technologies.[73] While scholarship seems quite consistent on the cruciality of ethics in AI systems, what remains quite complex and debated, is the implications of these guidelines and principles, and whether they actually work.[74] Nonetheless, the implications of these guidelines fall outside the scope of this study. Instead, the focus here is on the interplay between ITS and ethics. However, if the premise holds that ethics is central to AI and that ITS are a subset of AI systems, it logically follows that ethics is also central to ITS.

What, then, are these fundamental principles? In this regard, a systematic literature review has previously found that the most prevalent principles of AI ethics include transparency, privacy, accountability, and fairness.[75] There has also been a suggestion that unequal access constitutes a critical consideration, particularly in discussions concerning ITS.[76] What is of contextual importance to the education sector in Kenya, the recent Office of the Data Protection Commissioner's Guidance Note for the Education Sector (hereafter 'ODPC Guidance Note', 'Guidance Note', or other contextually related terms) also echoes these concerns.[77]

Therefore, it is essential for this study to evaluate the use of ITS within the framework of these principles, with a specific focus on the Kenyan context where applicable.

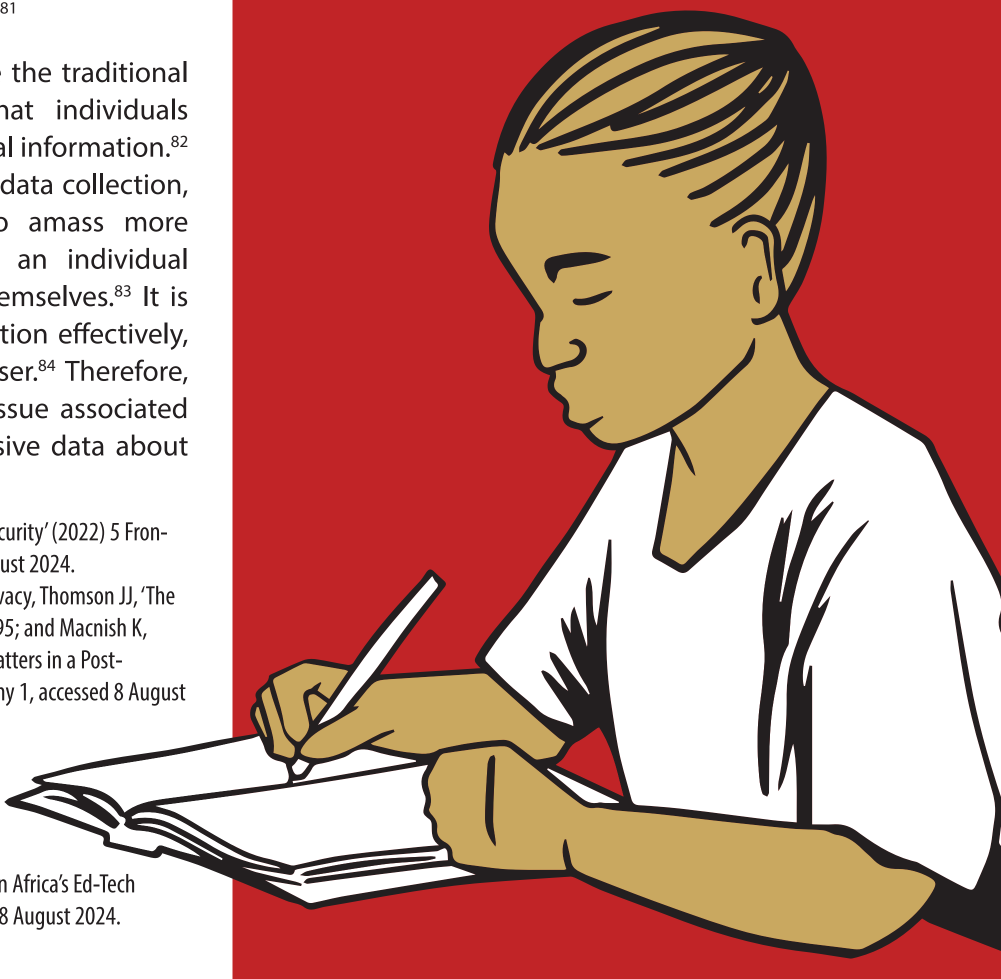
[67]ibid
[68]ibid
[69] ibid
[70]Choung H, David P, and Ross A, 'Trust and Ethics in AI' (2023) 38(2) AI & Society, 73, accessed 8 August 2024.
[71]See generally, Floridi L, Cowls J, Beltrametti M, Chatila R, Chazerand P, Dignum V, et al, 'AI4People—An Ethical Framework for a Good AI Society: Opportunities, Risks, Principles, and Recommendations' (2018) 28 Minds and Machines 689, accessed 8 August 2024.
[72]McNamee S, 'Ethics as Discursive Potential' (2015) 36(4) Australian and New Zealand Journal of Family Therapy 432, accessed 8 August 2024.
[73]See for instance, Jobin A, Ienca M, and Vayena E, 'The Global Landscape of AI Ethics Guidelines' (2019) 1(9) Nature Machine Intelligence 389; Hagendorff T, 'The Ethics of AI Ethics: An Evaluation of Guidelines' (2020) 30(1) Minds and Machines 99; Hickok M, 'Lessons Learned from AI Ethics Principles for Future Actions' (2021) 1(1) AI and Ethics 41; Whittlestone J, Nyrup R, Alexandrova A, and Cave S, 'The Role and Limits of Principles in AI Ethics: Towards a Focus on Tensions' in Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society (January 2019) 195, accessed 8 August 2024.
[74]Hagendorff T, 'The Ethics of AI Ethics: An Evaluation of Guidelines' (2020) 30(1) Minds and Machines 108, accessed 8 August 2024.
[75]Khan AA, Badshah S, Liang P, Waseem M, Khan B, Ahmad A, et al, 'Ethics of AI: A Systematic Literature Review of Principles and Challenges' in Proceedings of the 26th International Conference on Evaluation and Assessment in Software Engineering (June 2022) 383, accessed 8 August 2024.
[76]Lin CC, Huang AY, and Lu OH, 'Artificial Intelligence in Intelligent Tutoring Systems Toward Sustainable Education: A Systematic Review' (2023) 10(1) Smart Learning Environments 10, accessed 8 August 2024.
[77]Office of the Data Protection Commissioner, Guidance Note for the Education Sector (December 2023) 9, accessed 22 August, 2024.

6.1 Data Privacy & Security

In the preceding section, it was posited that ethics was a crucial topic of discussion within the AI discourse. An equally prominent concern regarding AI technologies is centred around privacy and security.[78] In this regard, privacy would not merely extend to the individual's ability to, say, prevent others from obtaining or using such information without their consent.[79] On the contrary, there is something deeper with regards to privacy that makes it so crucial in any AI-related exchange.

There are many reasons, generally, why the intersectionality between data privacy, security and AI is significant, including for ITS. A contextually apt starting place is the ODPC Guidance Note. The Guidance Note highlights many concerns, but its premise is based on the cognizance that the education sector brings up considerable privacy issues, such as the possible misuse of personal information, insufficient transparency in data collection and processing practices, and the risk of bias and discrimination in handling personal data.[80] The Guidance Note also raises concerns with the rapid adoption of educational technology which is likely to introduce new privacy challenges, as these platforms often collect extensive student data and may be targeted by malicious actors.[81]

AI systems fundamentally challenge the traditional notion of "epistemic privilege" that individuals typically hold over their own personal information.[82] Through extensive surveillance and data collection, AI systems have the potential to amass more comprehensive information about an individual than the individual may possess themselves.[83] It is well-established that for ITS to function effectively, they must collect data about the user.[84] Therefore, an ITS falls prey to the elemental issue associated with AI: it inherently collects extensive data about



[78]Elliott D and Soifer E, 'AI Technologies, Privacy, and Security' (2022) 5 Frontiers in Artificial Intelligence 826737, 1, accessed 8 August 2024.
[79]See, for a general view against the basic notion of privacy, Thomson JJ, 'The Right to Privacy' (1975) 4 Philosophy & Public Affairs 295; and Macnish K, 'Government Surveillance and Why Defining Privacy Matters in a Post-Snowden World' (2018) 35 Journal of Applied Philosophy 1, accessed 8 August 2024.
[80]ibid (n 77).
[81]ibid.
[82]ibid (n 78) 5.
[83]ibid.
[84]Odhiambo RA, Wakoli E, and Rodrot M, 'Data Privacy in Africa's Ed-Tech Platforms: Children's Right to Privacy' (2021), accessed 8 August 2024.

the person – or especially a child in this case – using the system, thereby accumulating comprehensive profiles that probably even surpass the child's own knowledge about themselves.

Furthermore, all AI systems inherently carry an elevated risk of privacy violations if the collected information is accessed by entities capable of forming perceptions based on that data.[85] This risk arises from the substantial amounts of personal data that AI systems can accumulate and store. A typical ITS grants instructors' access to the data collected by the system.[86] Consequently, instructors or tutors responsible for teaching a particular unit would access the data collected by the system to form their own perceptions about the children. This issue is exacerbated in the case of ITS because of the level of detail the system collects. ITS, inter alia, analyse the student responses to then create a multidimensional model of the student's psychological states – such as subject matter knowledge, learning strategies, motivations, or emotions – or by situating the student's current psychological state within a multidimensional domain model.[87] This, on face value, illustrates the challenges of the system with regards to security, notwithstanding, the mere existence of such extensive data on children presents an inherent risk, and the access to this data itself constitutes a significant concern.

What compounds the privacy issue regards the solution. While one may venture to observe and thereafter posit that privacy policies are instituted by the makers of such systems,[88] authorship criticises the effectiveness of these policies. N. Sadeh et al., argue that the sheer complicated nature of the policies, and the rarity with which individuals actually read them, there is a dearth in the number of persons able to comprehend the terms to which they are agreeing and the associated risks they face.[89] This position has also been corroborated and buttressed by J. R. Reidenberg et al. who observe that privacy policies are typically verbose, difficult to understand, time-consuming to read, and among the least-read items on most websites, thereby casting doubt on their effectiveness.[90]

For ITS then, the problems to overcome are many. But the overarching problem is that these issues are inherent to the system, thus making them harder to solve. There is suggestion of using things like design, including age-appropriate notifications, two-stage verification for parental consent, and easily accessible options for data subject rights like access and erasure that may solve these problems.[91]

6.2 Bias and Fairness

Bias, at least algorithmic bias, has been defined as the "inclination…of a decision made by an AI system which is for or against one person or group, especially in a way considered to be unfair… [in relation] to the gathering or processing of data that might result in prejudiced decisions on the bases of demographic features such as race, sex, and so forth".[92] The discussion on algorithmic bias and fairness is far reaching and continues to burgeon.[93]

[85]ibid (n 78) 6-7.

[86]Hase A and Kuhl P, 'Teachers' Use of Data from Digital Learning Platforms for Instructional Design: A Systematic Review' (2024) Educational Technology Research and Development 5; See also, Educause, '7 Things You Should Know About Intelligent Tutoring Systems' (2013) 2, accessed 8 August 2024.

[87]Ma W, Adesope OO, Nesbit JC, and Liu Q, 'Intelligent Tutoring Systems and Learning Outcomes: A Meta-Analysis' (2014) 106(4) Journal of Educational Psychology 902, accessed 8 August 2024.

[88]Ibid No. 14.

[89]Sadeh N, Acquisti A, Breaux TD, Cranor LF, McDonald AM, Reidenberg JR, Smith NA, Liu F, Russell NC, Schaub F, et al, 'The Usable Privacy Policy Project' (2013) Technical Report CMU-ISR-13-119, Carnegie Mellon University, 3, accessed 8 August 2024.

[90]See generally, Reidenberg JR, Breaux T, Cranor LF, French B, Grannis A, Graves JT, Liu F, McDonald A, Norton TB, and Ramanath R, 'Disagreeable Privacy Policies: Mismatches Between Meaning and Users' Understanding' (2015) 30 Berkeley Technology Law Journal 39, 8 August 2024. In this paper, the curated a primary study that sought to understand the effectivity and utility of privacy policies. The methodology adopted was a survey with a group of law students, experts, and lay persons. The study showed discrepancies in the reception of policies.

[91]Mougiakou E, Papadimitriou S, and Virvou M, 'Intelligent Tutoring Systems and Transparency: The Case of Children and Adolescents' in Proceedings of the 9th International Conference on Information, Intelligence, Systems and Applications (IISA) (IEEE, July 2018) 7, accessed 8 August 2024.

[92]Ntoutsi E, Fafalios P, Gadiraju U, Iosifidis V, Nejdl W, Vidal M-E, and Staab S, 'Bias in Data-Driven Artificial Intelligence Systems—An Introductory Survey' (2020) 10(3) Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery 3. You may also see Shin D and Shin EY, 'Data's Impact on Algorithmic Bias' (2023) 56(6) Computer 90, accessed 8 August 2024.

[93]Nah S, Luo J, and Joo J, 'Mapping Scholarship on Algorithmic Bias: Conceptualization, Empirical Results, and Ethical Concerns' (2024) 18 International Journal of Communication 549, accessed 8 August 2024.

Algorithmic bias can exist as various things within an AI system, but the definition postulated by Ntoutsi et al. above captures the core ideas of what bias entails in this context. In fact, to illustrate the varying degree of bias, the literature is brimmed exemplifying the kinds of biases.[94] Aside from criminal justice,[95] there is evidence of bias in all contexts,[96] such as hiring,[97] computer vision,[98] medicine.[99] However, overarchingly, algorithmic bias is termed as a problematic and 'harmful consequence' especially where social groups are unequal.[100]

Education is not saved from the far-reaching effects of algorithmic bias. In fact, there is evidence, since the 1960s, that education, generally, has suffered from bias.[101] And with the emergence of AI systems in education, such as ITS, one would not be faulted for assuming the prevalence of bias would be perpetuated. In fact, it has been said that this phenomenon is bound to increase,[102] and an example of the scale of the problem can no better be seen than the General Certificate of Secondary Education (GCSE) exams in 2020.[103] When the examiners used algorithms to grade students, the system scored lower grades to students in less fortunate backgrounds, and higher grades to those in private schools. Indeed, the foregoing example perfectly encapsulates the danger of algorithmic bias in the education sector.

In ITS, the deployment of these systems in school exposes them to children, who, from varying social groups and backgrounds study. As such, the 'harmful consequence' and problematic nature is exacerbated for an AI such as ITS, due to the place in which it is deployed. One might exemplify the workings of bias in various ways. For instance, an ITS designed to teach maths might inadvertently favour problem-solving approaches that align more with traditionally male-dominated learning styles, thereby disadvantaging female students or those who do not fit this pattern; or an ITS that relies heavily on data from Western educational contexts might not effectively support students from different cultural backgrounds. For example, it might misinterpret students' responses or struggle to relate to culturally specific problem-solving methods.

More crucially, the widespread adoption of ITS could lead to various inadvertent effects. One such effect is the perpetuation of a bias through material it is given. AI systems delivering educational content may inadvertently include biassed or culturally insensitive materials.[104] One might argue that this could be circumvented by merely being more careful in the material However, this is easier said than done, since the system could *inadvertently* continue to perpetuate a bias.

6.3 Transparency

Transparency is another crucial aspect of AI systems that has solicited much discourse among not just academics, but also a wider array of stakeholders, including policy makers.[105] It has been termed

[94]See generally: On predictive policing or crime prediction, see Benbouzid B, 'To Predict and to Manage: Predictive Policing in the United States' (2019) 6(1) Big Data & Society 1; Brantingham PJ, Valasik M, and Mohler GO, 'Does Predictive Policing Lead to Biassed Arrests? Results from a Randomised Controlled Trial' (2018) 5(1) Statistics and Public Policy 1; on social media protest policing, Dencik L, Hintz A, and Carey Z, 'Prediction, Pre-Emption and Limits to Dissent: Social Media and Big Data Uses for Policing Protests in the United Kingdom' (2018) 20(4) New Media & Society 1433; on bias in healthcare, see Obermeyer Z, Powers B, Vogeli C, and Mullainathan S, 'Dissecting Racial Bias in an Algorithm Used to Manage the Health of Populations' (2019) 366 Science 447, 8 accessed August 2024.

[95]Angwin J, Larson J, Mattu S, and Kirchner L, 'Machine Bias: There's Software Used Across the Country to Predict Future Criminals. And It's Biassed Against Blacks' (ProPublica, 2016) https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing accessed 7 August 2024.

[96]Baker R and Hawn A, 'Algorithmic Bias in Education' (2022) 32(4) International Journal of Artificial Intelligence in Education 1053, accessed 8 August 2024.

[97] Garcia M, 'Racist in the Machine: The Disturbing Implications of Algorithmic Bias' (2016) 33(4) World Policy Journal 111, accessed 8 August 2024.

[98] Klare BF, Burge MJ, Klontz JC, Bruegge RWV, and Jain AK, 'Face Recognition Performance: Role of Demographic Information' (2012) 7(6) IEEE Transactions on Information Forensics and Security 1789, accessed 8 August 2024.

[99] O'Reilly-Shah VN, Gentry KR, Walters AM, Zivot J, Anderson CT, and Tighe PJ, 'Bias and Ethical Considerations in Machine Learning and the Automation of Perioperative Risk Assessment' (2020) 125(6) British Journal of Anaesthesia 843, accessed 8 August 2024.

[100] Nah S, Luo J, and Joo J, 'Mapping Scholarship on Algorithmic Bias: Conceptualization, Empirical Results, and Ethical Concerns' (2024) 18 International Journal of Communication 551, accessed 8 August 2024.

[101] ibid (no 26), 1054.

[102]ibid (no 26), 1053.

[103] Smith H, 'Algorithmic Bias: Should Students Pay the Price?' (2020) 35(4) AI & Society 1077, accessed 8 August 2024.

[104]Teachflow, 'Assessing the Reliability and Bias of AI in Education' (30 June 2023) https://teachflow.ai/assessing-the-reliability-and-bias-of-ai-in-education/ accessed 7 August 2024.

[105]Larsson S and Heintz F, 'Transparency in Artificial Intelligence' (2020) 9(2) Internet Policy Review 9, 8 August 2024.

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Education is not saved from the far-reaching effects of algorithmic bias. In fact, there is evidence, since the 1960s, that education, generally, has suffered from bias.

as a fundamental privacy prerequisite.[106] This transparency issue is no easy task with which to deal, and the inherence of this problem is so widespread, that the academic community has dubbed it 'the black box problem'.[107] The black box problem "refers to the lack of transparency and interpretability of AI algorithms".[108] Much work has been done on demystifying this black box problem, but to little avail.[109]

The core issue is that many AI systems operate in a way that is opaque or "hidden from human comprehension".[110] Observers can see the inputs and outputs, but not the inner workings and decision-making processes of these complex systems.[111] Without understanding how an AI system reaches its conclusions, scholars have questioned the extent to which these systems can be trusted.[112] This opacity undermines a key requirement for transparency. Afterall, how can something opaque be transparent? The two are mutually exclusive states.

The black box nature of algorithms means we lack this crucial transparency, and therefore cannot make justified judgments about the trustworthiness of these AI systems.[113]

In an ITS, transparency is critical for providing personalised instruction to students based on their needs and abilities.[114] ITS uses algorithms and models to analyse the learner's knowledge, skill levels, learning styles, and even, as earlier mentioned, certain psychological parameters.[115] The decisions made by the system based on these analyses have a significant implication on the learner's education and therefore, must be transparent.

Transparency in ITS also enables better adaptation and refinement of the system. By understanding the AI's decisions, educators, developers, or AI experts can identify areas of weakness or potential bias in the system and work to correct them.[116]

6.4 Digital Divide

In a country like Kenya where infrastructure development for the digital age is slow at best, the gap the digital divide concerns itself with is an ever-growing concern. Infrastructure and connectivity difficulties contribute to the digital divide, lowering the chances for disadvantaged students to access educational tools such as ITS.[117] Dependable electricity, internet connectivity, and accessibility to personal computers or tablets are important to consider satisfying the infrastructural needs for adopting ITS efficiently. Policy guidelines should also describe the required infrastructure and offer suggestions for providing it to students living in rural and other marginalised areas in Kenya. The digital divide also arises due to a lack of enough capacity among teachers and instructors, necessitating teacher training and professional development to enable educators to use ITS in the classroom effectively.[118] Particularly, policymakers must recognise that ITS would not replace teachers, which calls for a participatory process in using ITS in

[106]Mougiakou E, Papadimitriou S, and Virvou M, 'Intelligent Tutoring Systems and Transparency: The Case of Children and Adolescents' in Proceedings of the 9th International Conference on Information, Intelligence, Systems and Applications (IISA) (IEEE, July 2018) 7, 8 August 2024.

[107]Blouin L, 'AI's Mysterious 'Black Box' Problem, Explained' (University of Michigan News, 6 March 2023) https://umdearborn.edu/news/ais-mysterious-black-box-problem-explained accessed 8 August 2024.

[108]Center for Scalable Data Analytics and Artificial Intelligence Dresden/Leipzig, 'Cracking the Code: The Black Box Problem of AI' (19 July 2023) https://scads.ai/en/cracking-the-code-the-black-box-problem-of-ai/#:~:text=The%20black%20box%20problem%20refers,at%20its%20conclusions%20or%20predictions accessed 8 August 2024.

[109]See for instance, Fomin VV and Astromskis P, 'The Black Box Problem' in Future Law, Ethics, and Smart Technologies: The Future of Legal Education (2023) 393 112; Von Eschenbach WJ, 'Transparency and the Black Box Problem: Why We Do Not Trust AI' (2021) 34(4) Philosophy & Technology 1607; Castelvecchi D, 'Can We Open the Black Box of AI?' (2016) 538(7623) Nature News 20; Wadden JJ, 'Defining the Undefinable: The Black Box Problem in Healthcare Artificial Intelligence' (2022) 48(10) Journal of Medical Ethics 764, 8 August 2024.

[110]ibid (no 91), 1607.

[111]V. V., & Astromskis, P. (2023). The Black Box Problem, 119, 8 August 2024.

[112]ibid (no 91), 1608.

[113]ibid (no 91), 1612-1613.

[114]Karpouzis K, 'Explainable AI for Intelligent Tutoring Systems' in FAIEMA 2023 - XAI in Education (2023) pp 1-10, accessed on 8 August 2024.

[115]Ma W, Adesope OO, Nesbit JC, and Liu Q, 'Intelligent Tutoring Systems and Learning Outcomes: A Meta-Analysis' (2014) 106(4) Journal of Educational Psychology 902, accessed 8 August 2024.

[116]Ibid (no 44), 3.

117Okello F, 'Bridging Kenya's Digital Divide: Context, Barriers and Strategies' (2024) Digital Policies Hub, Working Paper 1, accessed 8 August 2024.

118Joaquim S and others, 'What to Do and What to Avoid on the Use of Gamified Intelligent Tutor System for Low-Income Students' (2021) Education and Information Technologies https://link.springer.com/article/10.1007/s10639-021-10728-4#citeas accessed 9 August 2024.

The core issue is that many AI systems operate in a way that is opaque or "hidden from human comprehension

classrooms.[119] Hence guidelines should also provide recommendations for teacher training programs, ongoing support, and collaboration between teachers and ITS. Nontechnical infrastructure issues and a regulatory framework also cause the digital divide. It is therefore important to address these requirements in a wide national strategy for AI that considers the business, regulatory, educational, knowledge and infrastructural aspects of ITS.[120]

This aside, studies have found that there are six main barriers to ITS adoption in developing countries: students' basic ICT skills, ICT hardware availability, data costs, internet reliability, language, and lack of culturally appropriate content.[121] These barriers exemplify the consequence of the digital divide.

119 ibid

120 ibid

121 See also, Gulati S, 'Technology-Enhanced Learning in Developing Nations: A Review' (2008) 9(1) *International Review of Research in Open and Distance Learning* 1; Cassim KM and Eyono Obono SD, 'On the Factors Affecting the Adoption of ICT for the Teaching of Word Problems' in Ao SI, Douglas C, Grundfest WS, and Burgstone J (eds), *Proceedings of the World Congress on Engineering and Computer Science 2011* (vol 1, Newswood Limited, San Francisco 2011) 269, accessed 8 August 2024.

Kenya falls squarely within this category, and the digital divide is likely to be a huge consideration when it comes to ITS.

7. Policy and Regulatory Framework

Around the world, policy and legal documents that are best placed to regulate the use of ITS seem to have a very clear direction. This is because, even a superficial reading of the different documents reveals a discernable pattern. The noticeable trend in question comes out of the core principles these documents espouse.

For instance UNESCO's AI document which provides several principles relevant to regulating intelligent tutor systems.[122] These include ensuring proportionality and avoiding harm, maintaining safety and security, promoting fairness, protecting privacy and data, maintaining human oversight, ensuring transparency and accountability, upholding responsibility, fostering awareness and literacy.[123] The document also includes the need

122 UNESCO, the Ethics of Artificial Intelligence, 2021, accessed 8 August 2024.

123 ibid, 20-24.

to conduct risk assessments, implement privacy-protective frameworks, making systems inclusive and accessible, providing explanations for AI-assisted decisions, and promoting public understanding of AI technologies.[124]

At the EU level, similar trends exist with the continent's flagship Data framework, General Data Protection Regulation – GDPR. To meet GDPR obligations, systems would have to provide clear information about data collection, processing purposes, automated profiling, data recipients, retention periods, and user rights.[125] While the phraseology might differ, it is clear in which direction the policy is leaning.

At the continental level, the very recent AU AI Continental Strategy not only echoes the principles that appear ubiquitous, but it goes a step further.[126] The strategy dedicates a section to AI in education. It outlines the potential of AI to revolutionise education in Africa by improving access, quality, and personalised learning. What is quite relevant, is that the strategy specifically outlines ITS as an avenue through which AI in education could be most beneficial.[127] However, while it generally highlights significant concerns with AI in education, it does not specifically deal with the issues with ITS. The general concerns raised regard data protection, the potential undermining of teachers' roles, and the risks to students' creativity.[128] To address these, the strategy calls for the modernization of curricula to include AI and computational thinking, the development of inclusive national AI policies, and the establishment of centres of excellence to foster AI research and best practices.[129]

In Kenya, the chief document that is best placed to regulate the use of ITS, is the Data Protection Act (hereinafter referred to as 'the Act').[130] Therein, various provisions would fit within the ambit of regulating such systems. These provisions include:

- ITS applications, which tailor educational experiences based on data analytics, must adhere to the Act's principles of lawful, fair, and transparent data processing.[131]
- Before data can be collected and processed – say a students' personal data – explicit consent must be taken, ensuring that users are fully aware of how their data will be used.[132]
- Given the potential high-risk nature of ITS, where significant decisions about a learner's educational pathway could be made automatically, the Act mandates that data controllers or processors conduct impact assessments to identify and mitigate any risks to privacy.[133]
- ITS providers are required to implement robust technical and organisational measures to secure personal data and must notify both authorities and affected individuals in the event of a data breach.[134]
- The Act places limitations on decisions made solely by automated processes, which is particularly pertinent for ITS, as these systems often involve automated decision-making that can significantly affect students' educational outcomes.[135]

8. Challenges in Implementation of ITS

The implementation of ITS in Kenya is largely affected by the digital divide particularly in rural areas and low-resourced urban areas. Inadequate infrastructural preparedness, lack of access to electricity, internet, and inadequate teacher training are severe challenges facing primary schools' computerization

[124] ibid

[125] Mougiakou E, Papadimitriou S, and Virvou M, 'Intelligent Tutoring Systems and Transparency: The Case of Children and Adolescents' in Proceedings of the 9th International Conference on Information, Intelligence, Systems and Applications (IISA) (IEEE, July 2018) 6, accessed 8 August 2024.

[126] African Union, Continental Artificial Intelligence Strategy (July 2024), 27-29, accessed 10 August 2024.

[127] ibid

[128] ibid

[129] ibid

[130] No. 24 of 2019.

[131] Data Protection Act 2019, s 25, accessed 8 August 2024.

[132] ibid, s 30 and 32

[133] ibid, s 31

[134] ibid, s 43

[135] ibid, s 35

in rural Kenya.[136] Other significant challenges of implementing e-learning in Kenyan primary schools include unstable electricity, inadequate ICT gadgets, internet fluctuation, and a lack of skills to integrate ICT into teaching.[137]

9. Policy Recommendations

9.1 Invest in Educational Infrastructure

The Kenyan government must bridge infrastructural gaps faced by some regions in the country, including reliable internet connectivity and necessary hardware and devices for ITS deployment. Internet connectivity in Kenya faces significant challenges despite a high mobile phone penetration rate of approximately 78 percent.[138] Geographical disparities and high costs particularly affect rural areas, where connectivity is much lower. As of 2021, only 31 percent of Kenyans had internet access, with urban areas like Nairobi showing much stronger connectivity compared to rural regions, highlighting the urgent need for targeted efforts to improve infrastructure in rural parts of the country.[139] Partnerships with telecommunication companies can hasten the expansion of internet access in rural and underserved areas, bridging the digital divide and enabling equitable access to ITS across the country.[140] Such investments should also focus on reducing the costs of electronic devices such as mobile phones, tablets and laptops, to allow lower income individuals to access these important resources.[141]

9.2 Establish Comprehensive Teacher Training Programs

Comprehensive training programs should be developed to equip teachers with the skills necessary to effectively utilise ITS and implement learning goals.[142] Without proper training, teachers may struggle to integrate ITS into their curricula, limiting the potential impact of these technologies on student learning.

9.3 Foster Collaboration for Contextually Relevant ITS Deployment

Collaboration between developers and education stakeholders is necessary to create ITS that align with the Kenyan curriculum and resonate with students' cultural backgrounds. For instance, ITS systems must continually amend learning materials along with such amendments by the ministry of education. Additionally, partnering with local teachers and parents would improve the cultural specificity of these systems, to prevent situations where the systems illustrate concepts using Western examples and approaches.

9.4 Prioritise Ongoing Research and Evaluation

Prioritising ongoing research and assessment will help determine how ITS affects student learning results. To optimise the benefits of using these technologies in Kenya, a structure for monitoring and evaluation must be established by the Ministry of Education, to provide insights on how to improve and refine them over time. This is particularly important in areas where Intelligent Tutoring Systems are being used for the first time, as anticipated results might not be realised.

[136] J. Ogembo, Benjamin K. Ngugi and Matthew Pelowski. "Computerizing Primary Schools in Rural Kenya: Outstanding Challenges and Possible Solutions." The Electronic Journal of Information Systems in Developing Countries, 52 (2012). https://doi.org/10.1002/j.1681-4835.2012.tb00371.x. accessed 8 August 2024.

[137] Juma R. Haji, Rose J. Shiyo and Nipael Mrutu. "Exploring Effective ICT Integration Strategies in Education: A Case of Two Public Primary Schools in Mombasa, Kenya." Journal of Education and Practice (2023). https://doi.org/10.47941/jep.1526. accessed 8 August 2024.

[138] Frederick Okello, 'Bridging Kenya's Digital Divide: Context, Barriers and Strategies' (2023) <https://www.cigionline.org/static/documents/DPH-Paper-Okello.pdf> accessed 8 August 2024.

[139] Frederick Okello, 'Bridging Kenya's Digital Divide: Context, Barriers and Strategies'

[140] Frederick Okello, 'Bridging Kenya's Digital Divide: Context, Barriers and Strategies'

[141] Frederick Okello, 'Bridging Kenya's Digital Divide: Context, Barriers and Strategies'

[142] Maxwell Fundi and others, 'Advancing AI Education: Assessing Kenyan In-Service Teachers' Preparedness for Integrating Artificial Intelligence in Competence-Based Curriculum'

9.5 Implement Robust Data Protection Policies

Existing data protection guidelines must be implemented to safeguard student information and uphold their rights in the digital learning space. This is key, especially considering that a large amount of personal data in this context belongs to children. As such, data handling in ITS must consider age verification, parental consent and the verification of the authority of parents, to ensure that such parents can implement child controls on ITS systems.[143]

[143] ODPC, 'Office of the Data Protection Commissioner Guidance Note for the Education Sector' (2023) <https://www.odpc.go.ke/wp-content/uploads/2024/02/ODPC-Guidance-Note-for-the-Education-Sector.pdf > accessed 12 August 2024.

10. Conclusion

The report on ITS utilisation in Kenya highlights its potential to improve educational outcomes by enhancing accessibility, personalised learning, and resource allocation. However, successful implementation requires addressing key challenges, including the digital divide, infrastructure gaps, teacher training, and cultural relevance. The report calls for investment in rural infrastructure, partnerships with telecoms for better connectivity, and affordable devices to ensure equitable access. It also stresses the need for comprehensive teacher training and culturally relevant content. Ongoing research and evaluation are crucial to refining ITS use, ultimately leading to improved educational outcomes in Kenya.

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