A Rationale for the Introduction of AI Education at an Early Age for Digital Equity

Susan W. Gitu[1] & Nobert O. Basweti[2]

[1]*University of Nairobi, Kenya (susangitu@gmail.com)*

[2]*University of Nairobi, Kenya (nobert.ombati@uonbi.ac.ke)*

**Corresponding author: susangitu@gmail.com*

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Abstract

This study sought to advocate for the introduction of AI education in early childhood in Kenya and Africa at large. Studies indicate that AI will be a significant subject in the future, and this has forced most countries to start preparing for it. For instance, China has started teaching AI in both primary and secondary schools. Kenya on her part, has endorsed computer studies at both primary and secondary school levels even though computer studies do not dwell so much on AI fundamental topics. This study employed a systematic literature review to generate the merits of introducing AI education at an early age. The findings of the study indicate that introduction of AI education at the lower levels of education is advantageous for it will ensure digital equity; inculcate 21st century skills necessary for the 4th industrial revolution. It will also facilitate understanding of the basic functions and use of AI and AI applications. Lastly, AI education will meet the needs of future generations by preparing children for an unpredictable job market and a future with AI, inspire a novel generation of AI scholars and teach the succeeding generation of experts how to develop ethical and safe AI systems.

Keywords: Early Age, Education, Curricula, Generation, Computer, Digital Equity, AI Application

Introduction

The advent of artificial intelligence (AI) has generated excitement in the recent years (Jacobides et al. 2021). Its expansion has made it become immensely popular in the modern world (Mahato, 2022). Artificial intelligence has turned out to be a familiar term nowadays but still, we can deem it as a developing technology aiming at enhancing the fashioning of logical calculation of amounts, answers, result systems that will present smart and adaptive conducts, with a strong capability to master its surroundings just like human beings (Bhatnagar et al., 2021).

According to the European Commission (2020), AI is an agglomeration of technologies that put together algorithms, data and computing power. It refers to programming a computer or any device for it to carry out a task that traditionally was only achievable with human intelligence. (Becker, 2017). According to Mahato (2022), AI is a study that looks into how the human brain thinks, learns, decides and works when trying to solve problems. The principle aim of AI is to improve computer tasks which are linked to human knowledge like learning, reasoning, belief, problem- solving and linguistic intelligence. AI also refers to science and engineering utilized to create smart systems in the field of computer science, helping in technological advancement.

Kaplan and Haenlein (2021) define AI as a system's capability to interpret external data accurately, to master the data and use the knowledge to realize specific tasks and goals through flexible adaptation. It is a discipline of computer science that is concerned with intelligent machines where the agent of intelligence is a system that performs actions that maximizes its prospects of success. The core principles of AI include reasoning, planning, knowledge, learning, perception, communication and the ability to manipulate and move objects (Saini, 2023).

As the number of Artificial Intelligence applications increases world over, human beings have had more opportunities to interact with AI applications. This has made AI to be part and parcel of our lives; for instance, AI in computer games, Siri, smartphones, smart home appliances and Alexa (Ayanwale et al., 2022). If you decide to talk to your phone or Amazon's Alexa, the software that is instrumental in interpreting your voice is powered by AI (UNESCO, 2019). All virtual Assistants be it Siri or Google Assistant are based on the notion of Artificial Intelligence (Mahato, 2022). Artificial intelligence is indubitably an implement that already has a noteworthy impact on the general public and will have an even considerable impact in the foreseeable future (Slapczynski, 2022).

Many people are acquainted with AI services and applications and employ them in places such as homes, recreation centers, schools but apparently a huge percentage don't know about the science and technology instrumental in making them work (Ayanwale et al., 2022). In cognizance of the need to have a skillful digital manpower to come up with solutions using these upcoming technologies, Kenya carried out curriculum reforms and inaugurated the Competency-Based Curriculum (CBC) which incorporated coding and digital literacy in elementary school. Moreover, computer science was commenced in junior secondary school (Fundi et al., 2024). These reforms were driven by the need to arm students with competencies that are compatible with the changing demands of the 21st century's skills. CBC aims at arming every learner with seven principal competence areas: critical thinking, communication and collaboration, problem solving, citizenship, self-efficacy, learning to learn and digital literacy. The latter component incorporated coding with scratch (Scratch Foundation, 2022) as a launching pad for computer science for learners to

develop computational skills and creativity. Despite the fact that the inception of coding was a well-timed intervention to address the technological gap identified by Cambridge University, 2023, AI is still not a component of the Kenyan curriculum (Fundi et al., 2024).

It is of the essence to meet the demands of society in relation to the effecting of the emerging technologies. Moreover, taking an educated and informed approach while prioritizing the interests of students, will resolve many of the problems plaguing Kenya by deploying artificial intelligence (Mutsotso et al., 2024). In this regard, it has been put forward to schools the idea that implementing AI should be started at an early stage in life and it ought to take place where children acquire their training (Kaindio & Wagithunu, 2014) but Kenya is still dragging her feet in this respect. What could be the reason? Are we blind to the significance of introducing AI education at an early age according to experts? This paper, therefore, sought to argue for the introduction of AI at an early stage in life.

Problem Statement

The world is now gearing up for a future with AI but Africa is notably lagging behind. Countries such as China, the USA, the United Kingdom among others, are already teaching AI Education in both junior and senior schools, strategically positioning themselves for a future with AI. On the other hand, many countries in the African continent are hesitant to follow suit. Kenya, for instance, is yet to integrate AI as a subject and pedagogy in its curriculum, and this limits its potential to play a significant role in the 4th Industrial Revolution. It is high time the country woke up and smelled the coffee. This study: therefore, set out to rationalize the introduction of AI as a subject in both junior and senior schools to equip the upcoming generation with 21st century skills which will enable them to compete favourably in the unpredictable job market occasioned by AI.

History of Artificial Intelligence

The idea of coming up with artificial intelligence (AI) and intelligent machines has been around for quite some time now, spanning centuries for it can be traced back to the 14th century (Griffiths & Kabir, 2019). Although it is hard to determine the roots of AI, it can be traced back to the 1940s, particularly 1942, when an American Fiction writer by the name Isaac Asimov published a short story titled 'Runaround'. The story was about a robot invented by engineers Mike Donavan and Gregory Powell. The plot revolved around the Three Laws of Robotics: a robot may not hurt a human being or allow a person to come to harm through inaction; it must carry out the orders issued to it by human beings except in situations where such orders would clash with the first law; a robot ought to safeguard its own life as long as such safeguarding does not clash with the first or second law. This fictional work inspired cohorts of scientists in the domain of robotics, computer science and AI among others (Kaplan & Haenlein, 2021).

At about the same time, an English Mathematician by the name Alan Turing invented a code breaking machine for the British government and named it 'Bombe'. Bombe was purposely developed to decipher the mysterious code utilized by the German army during the Second World War. Bombe is considered to be the first operational electro-mechanical computer. The compelling way in which Bombe was capable of breaking the Enigma code, a goal previously unattainable by even the best of human mathematicians, prompted Turing to think about the intelligence of such machines. This led him to publish his first seminal article in the year 1950 titled 'Computing Machinery and Intelligence' in which he described how to come up with intelligent machines and specifically, how to assess their intelligence. This came to be known as

the Turing Test, which is still deemed today as a criterion to determine not only intelligence but also an artificial system: if a human being is interacting with another human being and a machine, and a machine is incapable of distinguishing the machine from the human being, then it is regarded as intelligent (Kaplan & Haenlein, 2021).

The term 'Artificial Intelligence' was officially formulated six years later when John McCarthy- a computer scientist and Marvin Minsky organized a workshop named 'Dartmouth Summer Research Project on Artificial Intelligence (DSRPAI) in the year 1956 at Dartmouth College, New Hampshire. This marked the onset of the AI Spring (Kaplan & Haenlein, 2021). Seemingly, the term 'artificial intelligence' was first mentioned in this workshop (McCorduct, 2004).

AI was instituted as an academic discipline in the 1950s. In spite of many early wins, AI remained a domain of relative scientific enigma and scanty practical interest for over half a century (Kaplan & Haenlein, 2021). Progress in AI was more sluggish than anticipated, and many researchers ended up disillusioned with the discipline, between 1970s and 1980s. Despite this, the advent of machine learning characterized 1990s and the development of high-powered novel computing technologies such as deep learning, assisted in reinvigorating the field and paved the way for new developments in AI (Alpaydin, 2010).

AI is no longer restricted to the laboratory or specialized uses in some abstruse scientific field. Presently, AI is a high- priority. The Future of Jobs Report that characterized the World Economic Forum (2018), identified AI as the heart of an agglomeration of technologies that are positioned to dominate the modern era, as drivers positively influencing business growth (Jacobides et al., 2021). According to the PWC's Global Artificial Intelligence Study 2017, the AI industry could be valued at not less than 15 trillion by 2030. Cognitive Technologies like robots, machine learning, AI and automation will supplant 16% of jobs by 2025 (Jacobides et al., 2021). Many companies are fixated on advancing AI in their systems and products in order to create a better user experience (Mahato, 2022).

The future of AI is a subject of much debate and speculation for the technology is developing at a very high rate, and its possible applications are extensive. There is no doubt that Artificial Intelligence will be utilized on a wider scale due to the likelihood of making money by providing convenient solutions (Slapczynski, 2022) thus it is worth investing in.

Methodology

The study used a systematic review of literature because of the numerous studies already done on artificial intelligence. The researchers consulted the university library and pieces of advice were given with regard to suitable databases and search terms to utilize during the process of collecting data. A meticulous search was done on different databases such as digital library, Google Scholar, Science Direct and Scopus to find information on Artificial intelligence. This method came in handy to locate the most relevant and latest information on artificial intelligence in order to draw conclusions pertaining to the study. The studies were methodically organized based on background information; literature review and the findings related to the study.

Impacts of Artificial Intelligence

AI technologies have developed to the point of offering actual practical gains in most of their applications. Crucial artificial intelligence domains include expert systems, speech understanding, sensory system, computer vision, intelligent computer added instructions, neural computing and scene recognition (Verma, 2018). An entire range of AI –enabled inventions and services are already in the market ranging from face-recognition to search engines, bots and call-center boxes to medical diagnosis, autonomous driving just to mention but a few (Jacobides et al., 2021). AI is an important accompaniment to the Internet of Things, credit to the technologies such as computer, deep learning, natural language processing, vision and machine learning in optimization and time-tested predictions, among others (Kuleto et al., 2021).

AI will bring about changes in our lives by promoting healthcare; for instance, in making diagnosis more accurate, facilitating better prevention of illnesses, among others (European Commission, 2020). Applications in healthcare include personalized treatment recommendations, drug discovery, medical imaging analysis and risk assessment. Moreover, AI is used to analyze electronic health records and supply patients risk evaluations, giving room to early intervention and improved results (Slapczynski, 2022). In the near future, AI could help in the management of patient care more efficiently (Kohli & Ahuja, 2019).

As the internet of things (IOT) is expanding, AI is potentially able to play a more important role in running smart homes, towns and cities. AI could come in handy to assist in optimizing energy utilization, improving transportation systems and enhancing public safety (World Economic Forum, 2018). It will also increase the efficiency of farming, contribute to climate change, mitigate and adapt, improve efficiency of production set-ups through increasing security and predictive maintenance (European Commission, 2020).

There are scores of examples of how AI is being deployed in business circles. Since the year 2015, Google has been using its RankBrain AI application for advertisement purposes, comprising chat bots, product recommendation, data analysis, dynamic pricing among others. An important impact is being brought about by machine learning (ML) and AI, as regards evolution of numerous economic and educational quarters and the general quality of people's lives. ML is among the most critical fields that can be utilized to uncover cyber-attacks on the Internet of Things. (Kuleto et al., 2021).

AI has also infiltrated the world of education. 'Adaptive', 'intelligent' and 'personalized learning systems' are progressively being advanced by the private quarters for utilization in schools high education institutions around the world (UNESCO, 2021). The notion of Artificial Intelligence in Education (AIED) is considerably a much younger discipline but the last 25 years have seen the introduction of Artificial Intelligence into educational sessions. An area of focus of AIED has been teaching, ensuring efficiency as in human- tutoring that takes place in interactive learning environment. (Griffiths & Kabir, 2019).

Despite the fact that there is a considerable body of research on AI, little attention has been devoted to the way AI systems are imparting AI education early in life (Hirvonen et al., 2023). While AI at present time remains an extraneous feature of the majority of schools and universities, the manner in which 'early adopted' AI-driven implements and applications have already come to be relevant to educational processes and general practices, raise several contentions that need to be taken earnestly over the next years (Selwyn, 2022). AI is the most advanced novel technology that presents new and the greatest hope for the next industrial revolution (Slapczynski, 2022). Hence, it is necessary to promote technological understanding

among people, enabling them to navigate a growing digital world and contribute to the debate on how AI should be deployed (Esterez et al., 2019).

Introduction of AI Education Early in Life

Artificial intelligence is escorting a whole generation of kids growing up in a fast-transforming digital world (Yang, 2022). In order to establish an evolving and efficient digital ecosystem, many techniques and technologies, intrinsically obtained from artificial intelligence have been researched and developed (El Haji & Azman, 2020). We are on the verge of a series of revolutions, specifically socio- technical revolutions. The upcoming revolution is industry 4.0, a revolution that will be characterized by artificial intelligence as the principal aspect (Kalantzis & Cope, 2019). This is the main reason why, artificial intelligence is being prioritized by countries round the world; for instance, the US government is focused on doubling its non-defense research and evolution. The European Union has demanded a 24 billion dollars investment in AI research and development by 2030. China on her part is aiming at investing 150 billion dollars in its local AI market (Jacobides et al., 2021).

With the intensifying computer power, a soaring sophistication of algorithms, and the mushrooming of data, artificial intelligence is attaining a noteworthy progress affecting many areas of our lives (Wang & Cheng, 2021) Revolutionary digital solutions spring up almost every month from quarters that are as varied as possible. Therefore, scrutinizing the implications of the emerging technologies in relation to education is very essential. Every country is undergoing disruptions such as changing jobs, shifting geopolitical powers or lack of educational applications attributable to the new technologies like 5G, AI or robotics, which call for a new mindset and novel educational methodologies (Bucea- Tonis et al., 2022).

Governments are spending highly in the domain of AI enabled digital learning. In India, the New Education Policy (NEP) 2020 that outlines revolutionary changes, puts strong emphasis on the modern–day subjects like Artificial Intelligence, virtual Reality, Machine Learning, and Design Thinking among others. The utilization of digital learning tools begins from kindergarten level which slowly increases to the higher education level. (Bhatnagar et al., 2021). In a spearheading move, the British Parliament recommended the education on AI fundamental topics to start from high school so that future generations will be in a position to cope with the upcoming social and technological challenges (Esterez et al., 2019).

The inauguration of the Beijing Consensus (UNESCO, 2019), the first-ever report on AI and education espoused by the UNESCO member states, has forced education policy makers and leaders worldwide to appreciate the necessity of charting the future of education in the light of artificial intelligence (Wang & Cheng, 2021). A study that was carried out by the European Commission indicates that each European member state has begun integrating Computer Technology in their own educational curricula though they are at different stages of doing so (UNESCO, 2019).

The traditional literacy which incorporates being able to read, write and calculate as regards mathematics, computer science and AI literacy, will become an important matter in the future. Although computer science education does not give prominence to AI elementary topics, countries such as Kenya, enacted a National ICT Policy in the year 2006 to mainstream ICT into the teaching and learning process (Farrell, 2007). China on her part has already begun teaching AI education in both primary and secondary schools (Ayanwale et al., 2022). UNESCO report (2022), points out that eleven countries at the present time, have government-approved curricular with a couple of other countries in the developmental phase. Researchers

aver that formal education should prioritize AI literacy and teach children how to interact with AI applications properly (Ayanwale et al., 2022).

Africa regrettably has one of the lowest ratings on the Global Government Intelligence Readiness Index (2020). A study conducted by Oyelere et al (2022) discovered that AI in K-12 education in the African continent is extremely missing. While there is lack of research on teaching and learning AI in Kindergarten through to high school in Africa, little work has begun to scrutinize this avenue. (Ayanwale et al., 2022). The crux of the matter is, if we blindly move forward, we should anticipate witnessing growing inequality and economic disruption, political instability, social unrest side by side, with the technological under-represented and disadvantaged faring the worst (UNESCO, 2021).

The significance of educating the succeeding generations in the apprehension of the basics of the next scientific and technological revolutions cannot be over-emphasized. Currently, large masses of people have scant understanding of the operations and implications of AI applications that are already infiltrating lives in many ways. (Esterez et al., 2019). We have a new role to make sure that society in its entirety is AI-literate in order to deploy these new technologies appropriately, effectually and ethically (Becker, 2017). The growing presence of artificial intelligence in all facets of human activity evidently conveys a necessity to operationalize 'ICT competencies' more than digital literacy in which computer technology becomes crucial (UNESCO, 2019).

Merits of AI Education Early in Life

The quick adoption and deployment of AI in the economy brings new challenges for governments and specifically education stakeholders. What kind of knowledge and skills should be developed by formal education systems, given the current developments? Research conducted recently approximates that 14% of the present job could vanish due to automation in the next twenty years, and another 32% are probable to transform radically. This means that a considerable demand for skills will also metamorphose, and so should the supply (Vincent-lancrin & Van der Vlies, 2020).

Governments and agencies are progressively starting to realize that (Ayanwale et al., 2022) possessing the needed skills and a good apprehension of AI tools can be essential for children to shine and adapt to the society faster; hence, education systems have begun to alter their curriculum and skills specifications, and strongly emphasize on skills needed for citizenship and innovation in the digital era (Vincent-Lancrin & Van der Vlies, 2020). The G20 AI propositions appreciate the changing nature of skills needed to cope with the changing economies and societies and propose that governments should work hand in hand with stakeholders to not only empower the citizenry to utilize AI but also furnish them with skills that will assist workers to undergo a fair adjustment as AI is deployed. While it has to progress over a lifetime, this initiative begins in school, elementary, vocational and tertiary education (Vincent-lancrin & Van der Vlies, 2020).

Initiating computer technology related instruction right from early education is a common phenomenon in the European countries (UNESCO, 2019). Bridging the AI skills gap extends beyond the espousal of increasingly high-powered technologies to facilitate learning. This translates to rethinking the content and methods employed in delivering instructions at each level of education (UNESCO, 2019). Modern students should be readied for future businesses and be in a position to solve various problems through using the

transversal skills obtained. This would make them have a competitive advantage that would facilitate an effortless transition from school to the business world (Bucea-Tonis et al., 2022).

Education plays a crucial role in its efforts to ensure that the future workforce is ready for AI (UNESCO, 2019). Education systems that are incapable of growing at the same pace, at which industries evolve, curb access to the skills required to promote a thriving economy and negatively influence global productivity (Kovoliuk & kobets, 2012). The prospects of youthful people are quickly changing, and those who possess AI-related skills may have an upper hand in the future. Education structures need to satisfy the needs of future generations by preparing children for a future with AI, making them aware of it and preparing them for an unpredictable job market (Ayanwale et al., 2022).

In addition, critical thinking and creativity are becoming more and more significant in the labour market, promoting a better civic and personal life. The speed at which information flows on the internet focuses attention on the importance of cognitive skills. Possessing higher cognitive skills such as literacy or problem solving, numeracy skills in a technology-rich environment, notably increases the probability of people moving from deploying the internet for communication and information to a more varied and intricate use, taking other factors into account (Vincent-lancrin & Van der Vlies, 2020).

Creativity is pivotal in the development of novel solutions which up until now have not been generated by computers (Vincent-lancrin & Van der Vlies, 2020). Previous evidence indicates that AI-enabled interfaces aid children in accessing digital content and services through child-computer interactions like gesture, speech and touch. Preschool children's interactivity with AI-interfaced robots or toys can improve their collaborative enquiry, emotion, creativity and related literacy skills. In addition, previous studies also indicate that learning about AI can boost children's creativity, computational thinking, collaborative enquiry skill, adaptive behaviors and language skills mainly because children's exposure to AI and understanding of AI will allow their thinking about AI-technologies to be more nuanced (Yang, 2022).

Luo et al. (2024) have explored opportunities and dangers of integrating AI into early childhood education. On a positive note, they bring to light AI's potential to transform the learners' educational experience by; for instance, adjusting the learning experience to their personal needs and capabilities thus maximizing the level of achievement of the intended aftermath of the learning process (Adel, Ahsan, & Davison, 2024; Fütterer et al., 2023). This is besides the interactive support of the AI tool in helping learners to get constant writing tips and cues in terms of building their vocabulary and expression thus encouraging the creative thinking skills of the budding learners (Bettayeb et al., 2024; Li et al., 2024; Samala et al., 2024).

The introduction of AI education at an early age will teach the next generation of experts and professionals how to come up with safe, ethical AI applications in fields like finance, medical and automobiles (Ayanwale et al., 2022). There have been concerns about ethical issues with regard to AI. Luo et al., (2024) address the ethical implications of AI; for instance, being overly reliant on AI to an extent of tampering with their innate development of critical skill: how to analyze and think about situations, and the risks associated with distorted content based on how the AI is (mis)guided (Adel, Ahsan, & Davison, 2024; Fütterer et al., 2023; Yang, Dong, & Yu, 2024, Ghimire & Edwards, 2024). In mitigating the upside and downside effects of AI on early childhood education, Chen & Lin (2024) have proposed the POWER principles to maximize the merits and minimize the demerits of AI in education for the young learners: purposeful, to act in a way that indicates patent motivation, intention and comprehension of what one aims to attain, why and how to

attain it; optimal, to act in a way that deploys a technology to its maximum potential, in the most effective and efficient ways to attain the best results/outcomes; wise, to act in a way that indicates thoughtful consideration and good reflection and sound judgment, by taking into consideration varied factors such as ethical concerns, advantages and disadvantages; ethical, to act in a way that is compatible with an assortment of moral principles or values ;for instance, integrity, honesty, equity and justice; responsible, to behave in a manner that demonstrates good judgment such as making choices and decisions with accountability and safety in mind, and paying attention to doing good and not harm (Chen & Lin, 2024).

Studies indicate that children hailing from low socio- economic backgrounds would be disadvantaged in relation to advancing their utilization of AI-enabled devices because of their inexperience in interacting with AI technologies. Digital divide has been shifted to AI domain, resulting in a pressing need to promote AI among children in classrooms in order to attain sustainable development goals and digital equity in early childhood education. Knowing and comprehending the fundamental functions of AI and utilizing AI applications is part of digital literacy for every person in a progressively intelligent society. Since we are espousing an AI-enabled era, we ought to ensure that every child and their families, can access digital literacy training in addition to using digital technologies comprising AI technologies (Yang, 2022).

Children have the capacity to apprehend the fundamental functions of AI, particularly when they are furnished with learning opportunities which are age appropriate. Most people are concerned that children may not be in a position to attain a meaningful comprehension of AI-technologies. Instead of doubting their capability in learning about and with AI-technologies, we need to allow children to create avenues to ask questions and manipulate AI toys appropriately and safely in their playful interactivities with their peers (Williams et al., 2019). Studies indicate that children as young as four-year-olds are in a position to utilize abstract concepts such as cause-effect relationship, and logical ordering that are extensively deployed in technical inquiries as a component of digital literacy. Learning AI at an early age is capable of narrowing down the digital divide in early childhood education (ECE) and realizing digital equity and inclusion in the long run (Yang, 2022).

Due to the quick progression of digitalization of our day-to-day tasks, AI education is now a key facilitator for future golden opportunities where knowledge, creativity and the possession of pertinent skills will be critical for success. Africa is the most populous continent in the world hence with a higher percentage of young people compared to other parts of the world. As a consequence, the burgeoning initiatives and awareness in K-12 in relation to AI education across the world should also be looked at through an African lens. A youthful citizenry translates into a substantial potential for socio-economic development, creativity and working population. Thus, this class of people needs to acquire the skills needed to operate in environments that are characterized by human-AI alliances as the norm (Ayanwale et al., 2022).

In conclusion, Africa needs to prioritize AI education in schools to prepare itself for the 4th Industrial Revolution. Kenya has already made some baby steps towards ensuring digital literacy by allowing the introduction of computer studies in schools, but a lot needs to be done since computer studies do not look into AI-applications. In this regard, Kenya and Africa in general, need to rightly position themselves as more countries scramble to get their hands on the latest technology. Introduction of AI education at an early age will go a long way in preparing future generations for the 4th Industrial revolution and rightly position Kenya and Africa at large, with regard to these emerging technologies.

Recommendations

- Policies that prioritize AI Education should be formulated
- Professional teachers should undergo retooling as regards AI to enable them to handle AI as a subject
- AI pedagogy should be taught at the university and colleges to prepare teachers for implementation of AI education
- The government should inject resources into the education sector to facilitate implementation of AI education.

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