

Stakeholders' insights on artificial intelligence education: Perspectives of teachers, students, and policymakers

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ABSTRACT

The integration of artificial intelligence (AI) as a subject into K-12 education worldwide is still in its early stages and undoubtedly needs further investigation. There is limited effort on understanding policymakers, teachers and students' viewpoints on AI learning within the school system. This study gathered the thoughts of key stakeholders, including policymakers, higher education and K-12 teachers, and students in Nigeria, to understand their conceptions, concerns, and dispositions, with the aim of aiding the implementation of AI in schools. We further explored the needs of the diverse stakeholders, how they can be supported and juxtaposed their views to identify their priorities and how their opinions combined could give a holistic approach to the effective implementation of AI education. This research employed a qualitative methodology using semi-structured interviews as the means of data collection. The thematic analysis of the interview data from the 21 participants indicates their conceptions, what they considered the priorities for including AI in the school system, concerns and support needed to implement AI in schools. The findings of this study contribute to the ongoing conversation on how to effectively integrate AI into school curriculum.

1. Introduction

The increasing impact of artificial intelligence (AI) in almost every facet of human lives has necessitated that everyone understands the basics of how the technology operates [1,2]. As a result, teaching AI within the compulsory education level and high school has been proposed as a critical strategy to prepare the teeming youth for an AI-enabled future. The realization of the importance of learning AI in K-12 systems has inspired the creation of different learning resources including tools, curricula materials, teaching approaches and teacher

education opportunities [3]. While studies should focus on resources and approaches to demystify AI to the young population owing to the newness of the initiative, the teachers, students, and policy makers perspectives' must not be secondary. One of the first steps to effectively introduce AI at the pre-college level is to convince policymakers, have teachers ready to accomplish the task and have students interested and motivated in learning the concept. These three stakeholders are key, judging from various grounds.

Adopting a new subject as a curricular material requires the analysis of the state's policy and future needs. Education policymakers are the

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primary gatekeepers as they are highly influential in determining subjects that are implemented in schools. By doing so, policymakers need to be convinced of the benefits of incorporating the subject into the official curriculum. With regards to teachers, adopting a new course or content would be impossible without teachers' buy-in [4]. Besides, teachers' belief in the relevancy of teaching AI and understanding of the same will translate to classroom reality. This assumption is corroborated by earlier studies [5,6] that the engine of beliefs is the one that drives instructional pedagogy. In addition, Ayanwale et al. [[7], p9] argued that "the success of AI education is closely dependent on the readiness of teachers." For student participants, evidence exists in the literature that students' perspectives and learning need to be considered, especially as it concerns introducing a new course or subject area [8,9]. It has also been established that the conception and perspectives of students, teachers and relevant stakeholders in teaching and learning are considered essential for teaching practices.

The overall goal of this study was to explore how different stakeholders (education policymakers, teachers, and students) regard the introduction of AI in compulsory school education and how it can be effectively implemented in Nigeria. Based on the crucial role of education policymakers, teachers, and students in school education, as earlier stated, it is imperative to understand their conceptions, concerns, and disposition towards learning AI in schools. In order to achieve our aim, this study seeks to explore the following research questions based on responses from selected participants in Nigeria.

- (1). What are the different stakeholders' conceptions of AI and priorities for inclusion in the formal curriculum?
- (2). What concerns do the stakeholders have with regard to the teaching of AI in schools?
- (3). How should the stakeholders be supported to develop AI literacy in the school system?

We provided answers to the research questions through a one-to-one interview with 21 education stakeholders (policymakers, teachers, and students) in Nigeria. Through a thematic analysis process, we uncovered different stakeholders' conceptions of AI, why AI should be included in school curriculum, what are concerns for AI adoption in schools and how different stakeholders can be supported to implement the subject in schools. The next section presents a review of related research considering AI in K-12 education and the role of the different stakeholders in K-12 AI education. Section 3 detailed the methods and approaches employed to conduct the research including the demographic details, data collection method and data analysis. Section 4 presents the result based on the analysis of the interview data. Section 5 discusses the results based on the research questions including the study implications. Section 6 concludes the study and highlights the research limitations and future research.

2. Literature review

2.1. AI education in compulsory level of education

The rapid integration of AI into K-12 education represents a significant shift in educational paradigms, reflecting a global trend toward preparing students for a technologically advanced future. As AI technologies are increasingly integrated into various sectors of our society, educational systems worldwide are adopting AI-centric curricula to equip students with essential skills and understandings from an early age. AI education initiatives within K-12 systems globally demonstrate a strategic response to the growing influence of AI technologies in all societal sectors. The integration of AI curriculum varies from country to country, with significant examples from Estonia and China. Estonia has incorporated coding and computational thinking from early education onwards. At the same time, China has developed a comprehensive curriculum that introduces students to robotics and machine learning at the

high school level. Also, various EU countries have introduced AI into their national curricula as part of broader digital education strategies. Another notable effort is the AI Basics for Schools project in India, launched as a collaboration between the government and private sectors [10]. This initiative focuses on integrating AI learning modules into the existing school curriculum. It provides both students and teachers with access to AI tools and resources, facilitating hands-on learning experiences that are critical for understanding the practical applications of AI (NITI Aayog, 2020). These efforts are supported by the need for educational policies to adapt and embrace AI as a fundamental component of modern education [11] and also a necessity for future workforce readiness [12].

These initiatives are a broader commitment to integrating AI into schools, as highlighted in the Future of Jobs Report by the World Economic Forum [13]. The literature also highlights the transformative potential of AI in education, such as through the use of adaptive learning platforms and intelligent tutoring systems, which personalise learning and cater to diverse educational needs [14,15]. Furthermore, non-governmental organisations play a vital role in augmenting these efforts. For instance, The Learning Partnership in Canada offers the 'Coding Quest' program, which includes AI education as part of a broader curriculum designed to enhance digital literacy among elementary school students. The program introduces students to AI concepts and engages them in creating their own AI-based projects, thus promoting active learning and innovation (The Learning Partnership, 2019). One of the significant challenges in AI education at the K-12 level is ensuring equitable access to resources. Disparities in school funding, teacher expertise, and technological infrastructure can lead to unequal educational opportunities (Roscoe et al., 2022). Addressing these disparities requires targeted policies and investments to ensure that all students, regardless of socioeconomic background, have access to quality AI education. As AI becomes more integrated into educational settings, ethical concerns also rise, reflecting a need to integrate discussions on the curriculum's societal impacts, privacy issues, and potential biases of AI technologies. This ethical discourse aims to prepare students to use AI responsibly and understand its broader implications on society. These initiatives reflect a global acceptance of the importance of integrating AI education into early educational stages. They emphasise the development of technical skills related to AI and the ethical dimensions of using such technology. By examining these programs, educators and policymakers can identify effective strategies and potential challenges in implementing AI education in K-12 settings. This understanding is crucial for developing educational practices that equip students with the knowledge and skills to navigate and shape the future AI-enhanced world.

Since the increased interest in AI education for K-12 students in 2018, there have been several efforts to support the initiative. The effort includes pedagogical design and AI framework [16], professional development program [17], conception of AI (Kim et al., 2024), researchers developed tools for learning AI [3] and curriculum activities [18] among others. While research works continue to unfold in the nascent field of AI for K-12 education, we have not specifically identified a study that considered policymakers' view on inclusion of AI as a school subject. There have also been limited investigations into how HEI teachers and students think of AI integration into basic education programs. To understand how the views of these different interest groups about AI integration into the school system and how their opinions combined could give a holistic approach to the effective implementation of AI education, we surveyed policymakers, teachers (HEI and K-12) and HEI students in Nigeria. There have been reports of paucity of research outputs in Africa [19] including Nigeria about AI education for young students. While work has begun to explore AI conception by school children including students' competencies to learn AI in Nigeria (e.g., [20,21]), there is a need to explore various educational stakeholders' perspectives about the topic.

2.2. The role of teachers, students, and policymakers in K-12 AI education

It is essential to prepare students for the challenges and opportunities that AI provides as it continues to influence our society. Several countries and educational institutions have made AI-related studies a requirement in their curriculum [11,22]. As these countries continue to integrate AI into their curriculum, it is important to highlight that teachers require sufficient training and professional development opportunities to deliver AI education effectively. Numerous projects have been launched to support and give teachers pedagogical and AI knowledge. For instance, the "AI4EU" programme of the European Union provides training courses for educators to improve their comprehension of AI and its implications [23]. Also, the AI4K12 initiative, developed by the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA), outlines five big ideas in AI education and provides guidelines for educators to introduce AI concepts to students across various grade levels [2]. Teachers often lack the required knowledge and training needed to teach AI-related subjects properly [7]. Investing in teacher professional development programmes and access to AI-specific training platforms are necessary to address this issue.

Learners who receive AI education in K-12 not only learn about new technologies and how they work but may also become future AI users, software engineers, ethical designers, and researchers [24]. However, compared to higher education, the K-12 curriculum design is more complex and challenging. Within and between schools, there is a much greater diversity of students' interests, abilities, and needs in K-12 education [25,26]. Additionally, schools have varying resources (such as AI learning platforms and tools) and visions (such as a high-tech or language-focused emphasis). For example, some schools may be able to teach students about ethics, while others may be able to teach them how to develop AI applications using cloud computing. Likewise, some teachers may be able to develop curriculums that help students learn about AI from a local viewpoint, while others may be able to develop their global perspectives. As a result, introducing AI curriculum globally to K-12 curriculum is challenging since how it is done varies significantly from school to school. Designing AI or AI-related courses is therefore difficult. According to recent studies on teachers' conceptions of teaching in technological contexts, teachers' conceptions of technology and their subject matter lie between teacher-centred knowledge delivery and student-centred knowledge construction continuums [27]. A more complex use of technology is linked to very sophisticated teaching concepts. Chen et al. [27] found that Chinese language teachers employ virtual reality to connect students effectively to the sociocultural milieu rather than only as a tool to improve exam performance. In the case of AI education, it is essential to map out how teachers envision imparting this cutting-edge knowledge to depict potential teachers' professional growth trajectories. This will help policymakers and researchers understand teachers' perspectives and facilitate teacher development. Different teachers' perspectives on AI education have shown their strengths and weaknesses when it comes to teaching AI, offering guidance to teacher educators and legislators on how to improve AI proficiency and advance comprehensive AI education.

According to Pijl & Frissen [28] education policymakers are saddled with the responsibility to improve and maintain the education quality, innovation implementation, and manage expenditures. Lueken and Shuls (2019) also described the role of K-12 policymakers in terms of making policy on funding K-12 education. The education policymakers fundamentally make policies that influence school practices, including funding, regulations, inspectorate, and legislation [28]. Ultimately, K-12 education policymakers are saddled with the responsibility of creating innovative and sustainable policies, including learning environments, that support effective teaching and learning. Several studies have explored policymakers' perspectives regarding education and its policies (e.g., [29,30]). For instance, Smakman et al. [31] examined the

perceptions of education policy creators on the impact of social robots on German education, which revealed the stand of Dutch education policy creators. In the context of AI education as a new subject for K-12 levels, the views of policymakers' matter since they provide directives and draw up guidelines for school curricula materials. Based on the role of these three educational actors – policymakers, teachers, and students – in ensuring we achieve a comprehensive AI education program in schools.

3. Methodology

This study utilized a qualitative method that involved audio-recording of individuals to investigate different education stakeholders' views on AI education, their concerns and how AI can be effectively integrated into K-12 education. Education stakeholders include policymakers, school teachers and higher education students. Twenty-one participants with different demographic profiles were selected to participate in the interview session, enabling the exploration of stakeholders' perceptions and also the reasoning behind these perceptions. The interview method was chosen because it allowed for a more in-depth understanding of participants' experiences and perspectives on the topic being studied [32]. Following the interview sessions, all audio recordings were transcribed and analysed using inductive coding. The thematic method was further applied to identify patterns within and across the data.

3.1. The procedure of interview sessions with the stakeholders

Individual interviews were conducted with policymakers, teachers, and students to gather data for this study. The interviews aimed to explore participants' familiarity with AI, their opinions on AI inclusion in school curricula, and their concerns and strategies for teaching AI. The interviews were guided by a set of questions that differed for each group of participants, as shown in the appendix. One of the authors interviewed the 21 participants on Zoom during January and April 2023. The participants' contacts were retrieved from the authors and researchers' colleagues. The participants were reached for the possibility to share their perspectives through informal conversations on different social media platforms. After the participants indicated interest in participating in the interviews, the interviewees and the interviewer agreed to meet at different times for the interview sessions. We attempted to collect perspectives of stakeholders from different study disciplines covering the STEM and non-STEM areas. Policymakers were asked about their opinion on AI inclusion in formal curricula and strategies that could be adopted to integrate AI into the school system. Teachers were asked about the relevance of teaching AI in schools, the implications of AI inclusion in formal curricula, and strategies for integrating AI into the school system. University students were asked about their opinion on AI inclusion in formal curricula, their experience with AI or Machine Learning (ML) courses, and how AI knowledge would have helped them if they had learnt it in school. The interviews were conducted online with participants' consent and audio recorded. Each interview lasted between 30 and 45 min, and all audio recordings were transcribed.

3.2. Participants

The study was conducted in Nigeria and focused on how AI education can be integrated as a subject in schools. Currently, Nigeria has not introduced AI as a subject or topic in the existing school curriculum even though computer studies is a subject in the compulsory grade levels. To understand how different educational stakeholders perceive the integration of the emerging technology concept in the school system, we consider teachers, governmental policymakers, and higher education (HEI) students as our study participants. Each participant provided a unique viewpoint on AI education, with teachers operating at the

forefront of instructional implementation, policymakers shaping the legislative and systemic framework, and students serving as the primary recipients of the educational outcomes. Table 1 shows the demographic details gathered from the participants.

This study engaged 21 participants, with 12 teachers (secondary and HEI), 6 HEI students, and three policymakers providing their perspectives on the subject. The criteria for participant inclusion were as follows: (i) participants must be teachers from primary schools to higher education institutions, (ii) policymakers involved in education or ICT-related boards, or (iii) students enrolled in primary, high school, or higher education institutions. The participants are distributed across the main regions in Nigeria (South and North). The HEI Teacher category of our participants is predominantly from the South region, while the HEI Student category has a more evenly distributed presence across the North and South regions. Regarding gender representation of each category, the student category has a higher representation among males (4) compared to females (2), similar to the teacher’s category. The secondary school teachers that were involved teaches different subjects ranging from civic education, computer science, mathematics, and English Language. The students were also from different fields which includes educational technology, curriculum studies, and computer science which is consistent with the HEI teachers that were interviewed.

3.3. Data analysis

Our analytical approach followed an inductive analysis process [33]. First, the authors designed a protocol for data analysis based on Structured Tabular Thematic Analysis (ST-TA) introduced by Robinson [34]. ST-TA provides a structural approach for analysing qualitative data with an in-depth interpretive understanding of small to moderately large text data. This method is considered suitable, especially in this study where qualitative data – although short interviews - were collected from relatively diverse and moderately large sample sizes. According to the ST-TA guidelines, preliminary themes may exist upon which codes emanating from the text data can be built. Moreover, this study formulates prior themes to align with the research questions, making the coding of data concise for concrete analysis. A meeting was held among the authors to discuss what should constitute prior themes, and consensus was reached, which includes (i) conception of AI, (ii) priorities for including AI in the curriculum, (iii) supports needed for developing AI literacy in schools, and (iv) concerns and apprehension for teaching AI in schools.

At the beginning of the data analysis, four authors independently read through the transcript to familiarise themselves with the responses and made notes of initial coding under each prior theme. One of the authors created a coding manual and shared it with three other co-authors to facilitate independent coding. After the coding round was completed, the authors met to discuss the codes, particularly how different codes converge, what the overlapping topics were, and whether some codes interlapped with multiple prior themes. During this discussion, some of the codes were refined, some were merged, and some codes considered to be redundant were removed. To ensure the reliability and internal validity of the research, the authors met for the second time using triangulation concepts to peer-review the codes, compare them across and arrive at a new code log. Based on this outcome of the peer-review of codes by the authors, one of the authors

Table 1
Demographic characteristics.

		HEI Teachers	K-12 Teachers	HEI Students	Policymakers
Sex	Male	5	5	4	3
	Female	1	1	2	0
Specialisation	STEM	4	4	4	2
	Non-STEM	2	2	2	1

created a table of final codes from which themes were formed. The transition of the analysis procedure is depicted in Fig. 1.

It is important to note that the prior themes suggested by the ST-TA protocol are useful strategies to extensively immerse in the data to discover meaningful codes. In the case of this study, each prior theme generated several codes that are analysed and presented in the result section.

4. Result

Based on the analysis of the interview data from the 21 study participants, we present the main findings as thematic models on the four areas of focus. As shown in Figs. 2-5, the four areas of focus are Conceptions of AI, Priorities for considering AI inclusion in the curriculum, Concerns about AI education implementation, and Support required for integrating AI education in K-12 levels. Notable is the fact that the respondents are diverse and consist of policymakers, educators, and students. Therefore, the result presentation will occasionally showcase the overall perception of all stakeholders and sometimes of specific stakeholders. Figs. 2-5 comprises three different categories highlighting the different perspectives of each group of participants, their shared perspectives, and examples of their common views.

4.1. AI conceptions

The analysis of the responses revealed that stakeholders’ conception of AI falls into three thematic areas. Thus, they conceive AI as a super cognitive technology, an assistive technology, or everyday computer technology. When they conceived AI as a super-cognitive technology, they believed that AI could make human-like decisions by being an intelligent system. For example, some of the respondents conceive AI as

“a collection of technology that work together to allow robots to, say interpret art and learn like humans just like human intelligence.”
Student 5

“a computer system that is able to perform the tasks that require human intelligence such as visual perception, speech recognition, decision making and translations between language.” *Teacher 3*

Similarly, some of the stakeholders conceive AI as sets of computer programs designed and trained to behave in certain ways. This particular conception of AI relates to the common belief that AI automation is trained to mimic human thinking and designed to handle tasks done manually by humans in workplaces. For instance, robotic computers are programmed to behave in this manner, which “reduces human efforts enhance,” and improves life in terms of productivity, efficiency, and turn-around time of industries.

In this sense, AI is viewed as an assistive technology since the purpose, as conceived by the stakeholders, being a technological invention, is to facilitate ease of doing things, thereby reducing the amount of human effort required to accomplish a task. Regarding this positive contribution of AI automation, students in Nigeria do not see its impact on education alone but on all aspects of life. For example, one of the students perceives AI thus:

“I think Artificial Intelligence has to do with the introduction of computer-related resources and accessories for day-to-day activities” *Student 1*

suggesting that the application of AI is possible in almost all aspects of human endeavour. Nowadays, there are smart AI systems embedded with sensors to intelligently perform several tasks. These systems are installed in both public and private places, collecting and processing varied data that is used to make intelligent decisions. As good as the study participants perceive the AI, there are concerns regarding how the data is being collected and what kind of data should be collected. These concerns are addressed in a separate section.



Fig. 1. Data coding procedure showcasing the transition from initial to final codes.

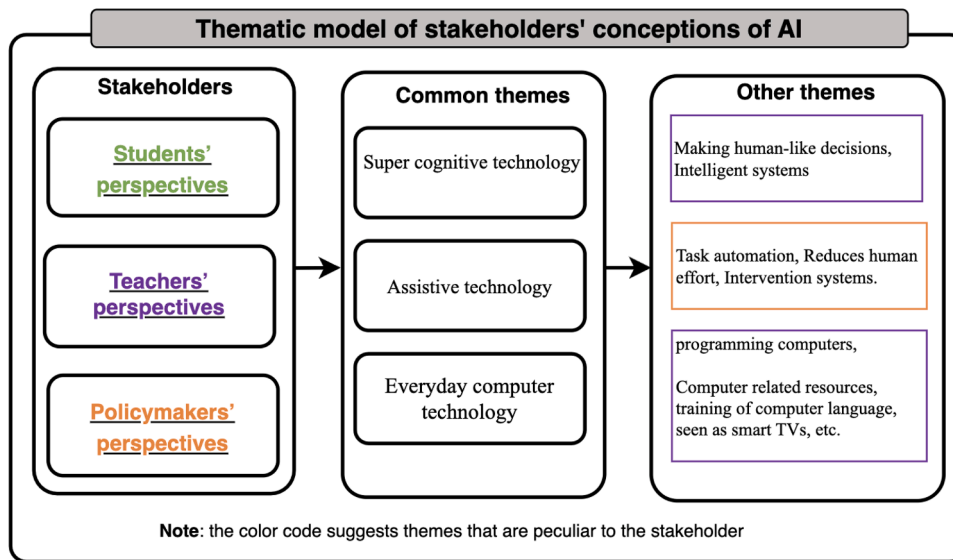


Fig. 2. Stakeholders' conceptions of AI.

4.2. Priority for including AI in schools

Part of the objectives of this study is to investigate stakeholders' perception of AI integration in schools and whether there is some form of expectation to make it a priority or not considering the advancement of AI in this digital age. The students, teachers, and policymakers alike considered the integration of AI in schools an important step that is apt, holding the view that young learners could be able to abreast with this technology in their earlier stage and grow to advance in it, thereby transferring the skills to societal development after graduation from the college. Although there were mixed feelings among the stakeholders regarding the extent to which the integration of AI in schools should be prioritised, one common thing is that its future relevance was acknowledged, which creates the necessity for developing its knowledge by integrating AI education into the classrooms.

One of the respondents stated that:

“... so, it is necessary to include it into the curriculum to limit the trend of digital divide.” Policymaker 2

For example, the students who are already in higher institutions responded with nostalgia to the question of prioritizing AI education in schools, stating that if they had the opportunity to learn the fundamentals of AI technology at the lower level, it would have benefitted their current study. Besides, they also expressed reservations in terms of the school's readiness for the integration of AI education, looking at the limited infrastructure and human resources. One of the students asserts thus:

“... because our schools are not well equipped with computers or machines that can aid this AI education, it could affect the priority it

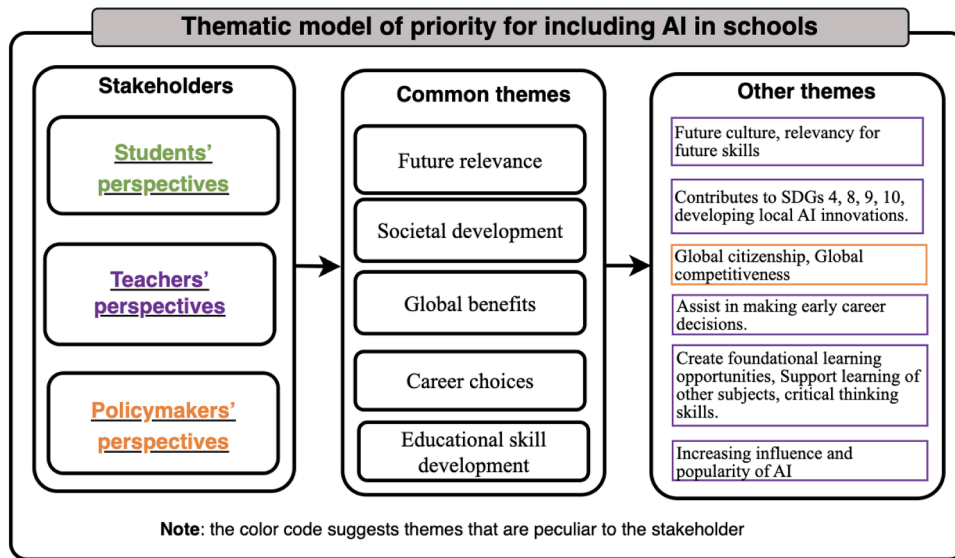


Fig. 3. Priorities for considering AI inclusion in the curriculum.

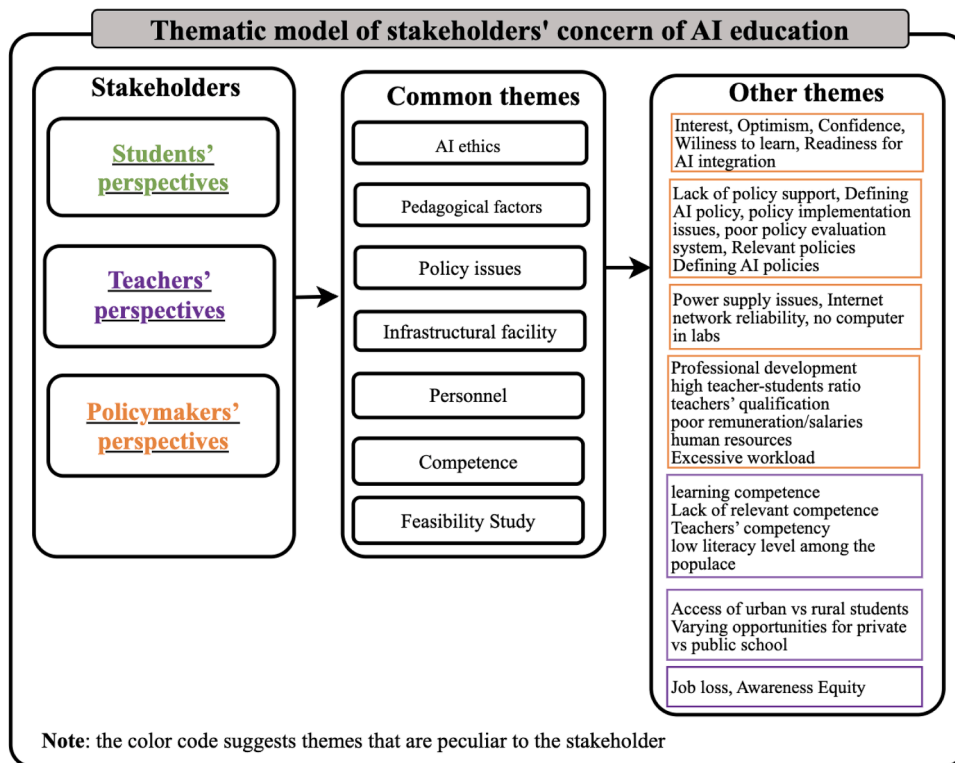


Fig. 4. Concerns about AI education implementation.

deserves. So, if they say they are going to include it in the formal curriculum as a priority, I think there will be difficulties, and the teachers too may need extensive training. I think, before they can be familiar with the concept before they teach. All these things will take a long period of time to achieve except the integration of AI in schools is done in a step-by-step approach.” Student 2

In addition, the teachers found the integration of AI in schools a fascinating agenda as they thought it would positively influence the teaching of other subjects and create an atmosphere for an equitable learning environment.

“If we key into AI education, it will help every student to have equal access to learning, irrespective of their learning ability or disability in the future.” Teacher 3

Also reported by the teachers is the fact that teaching AI in schools will facilitate students’ creativity and thinking skills, which is fundamental in STEM (Science, Technology, Engineering, and Mathematics) education as depicted in this excerpt from a response.

“... when we teach AI to students, one of the relevance is that they’re able to develop their critical thinking skills. Critical thinking skill is one of the 21st-century skills that all students must learn, and not students alone but even teachers.” Teacher 1

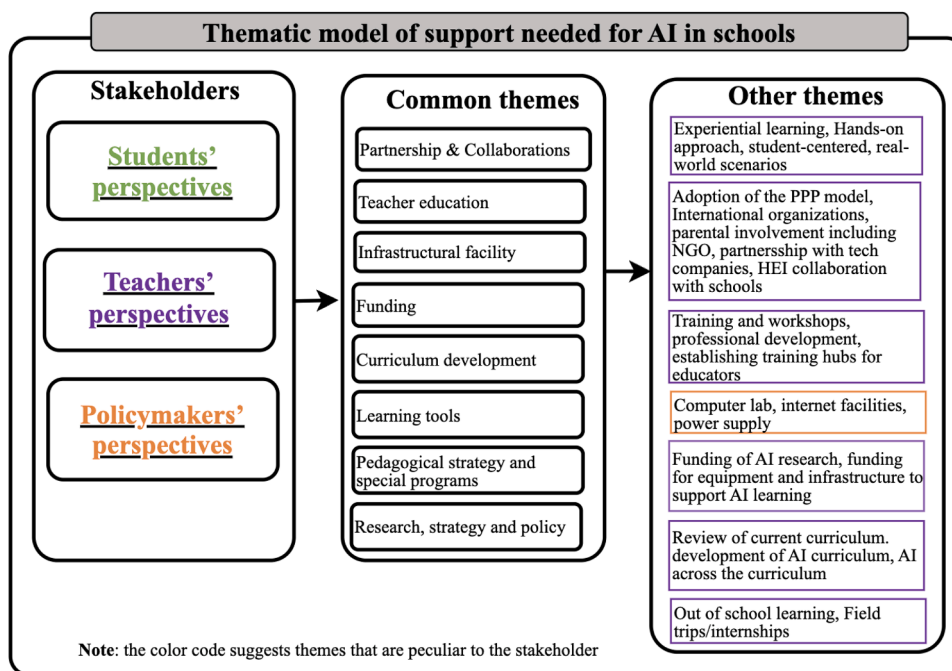


Fig. 5. Support required for integrating AI education in K-12 levels.

Similarly, some policymakers believe that AI education is a priority because the future of education will be massively influenced by the use of AI systems, thereby creating a compelling need for the government to support its fundamental education to prepare young learners for the future.

“... let's say five years or 10 years from now, we are going to witness a mega shift in an education system that is influenced by AI. And any country or educational system that is not waking up to this reality will be left behind.” Policymaker 2

Thus, to maintain global relevance engendered by AI technology, policymakers have the view that the integration of AI education in schools is a priority.

4.3. Concerns regarding AI implementation in schools

Different concerns were raised regarding integration of AI in schools. Our data showed that all the three relevant groups interviewed shared common concerns which centres on psychological factors, policy issues, infrastructure, personnel, and competence. Each of the represented groups stated other specific concerns. For instance, policymakers are concerned about feasibility studies – pilot programs indicating the feasibility of students learning AI in the K-12 levels. Teachers are worried about job loss, equity issues and lack of awareness of AI education among the general public. Students also view the ethics of AI as a concern.

With respect to psychological issues raised by the respondents, we observed that at various times in the transcribed data, there are terms commonly used by the three sets of participants. These include Interest in teaching or learning, Optimism, Confidence to teach, Willingness to learn, and policymakers' readiness for AI integration. Excerpts of the participants include:

“... the university and the government must be ready to train teachers and provide learning opportunity to teach AI.” - Teacher 6

“... the policymakers have a huge role to play because they must be interested in AI inclusion in our school curriculum.” - Student 2

“... there is a need to build the confidence of teachers in ensuring AI as a subject would be considered....” - policymaker 2

These different and overlapping views and words that kept reoccurring are an indication that psychological factors are considered relevant for implementing AI in schools. How these concerns could be addressed is important for developing AI for K-12 education.

The concerns expressed about the psychological factors are linked to personnel and competence. We deduced that a relationship exists among these concerns based on the expressions of participants (Policymaker 3) that “... teachers would be ready to facilitate AI to their students if they are provided with relevant training and AI knowledge.” Another participant (Teacher 2) mentioned that “I believe our children have the cognitive competence and capability to learn..... however, they may lack other relevant competence which may be from teachers' knowledge of the subject.”

Policy issues raised by the respondents include the need to define relevant AI policies, which include teaching AI in schools, how to ensure if the policies are made, they will be implemented and how the implementation would be evaluated if it occurs. The policymakers interviewed were concerned about reports from successful pilot programs investigating learning AI by students in compulsory school system. During the interview session, one of these policymakers (Policymaker 1) stated that “I am not aware of such report in this country...take some of these findings to the government and let's see the minister of education and Minister for state.....to see how we can push this AI education agenda in compulsory education.”

Consistent with a popular opinion about AI taking over teachers' job, teachers are concerned about job loss and the lack of awareness about teaching AI in the K-12 education system. Notable concern teachers have is equity issues which is specifically around equal access of urban versus rural and private and public schools' students to learning AI. An instance that indicates equity concern from teacher is presented thus:

“... otherwise, it might just be that some private schools will include AI as part of their subjects and the public schools' students would not be able to access AI content.” - Teacher 2

Another prominent reflection of students' opinion is ethics. In addition to other concerns, two students raised issues on ethical implications of AI as such mentioned that AI ethics should be considered to

understand the values of the emerging AI technologies. According to a student (Student 4) concern about ethic, he stated that “...nobody is talking about the fact that ethical and legal considerations are supposed to be taken into account before deploying or apply AI in most fields.”

4.4. Support needed for AI implementation in schools

Having uncovered how different stakeholders conceive AI, why they considered including AI in the curriculum as a priority and what their concerns are, it is imperative to gather their suggestions on how to effectively implement AI in schools. As shown in Fig. 5, Creating partnerships and collaborations, teacher education, infrastructural facilities, funding, curriculum development and learning tools. Policymakers believe that research reports are important including developing strategic policies on AI. Teachers also suggest designing special programs while both teachers and students agreed that appropriate pedagogical strategies should be identified to support AI in school’s initiatives.

Some of the stakeholders’ suggestions that formed the theme “partnership & collaboration” include adoption of public–private partnership (PPP) model, leveraging international organizations, parental involvement including NGOs, partnership with tech companies, HEI collaboration with schools. Interestingly, some of these recommendations are in tandem with some ongoing initiatives. For example, recent research has been conducted exploring how children and parents learn about AI together and how parents are involved in promoting AI learning [35, 36]. NGO’s support and HEI collaborations with schools has also been effective in teaching AI [2]. A teacher education program dedicated to AI education was proposed by the study participants. Some of the points raised include training and workshops, professional development, and establishment of training hubs for educators. Below is an example response that indicates these suggestions:

“... students in teacher education programs needs to be taught AI, in fact all students regardless the program or fields should benefit from AI knowledge.... the world is changing, and I think everybody no matter what they study should be able AI literate and AI knowledge.” – Teacher 3

The above quote despite the call for developing preservice and in-service teachers training calls for AI across the curriculum in HEI and schools which is tandem with existing research [37].

Funding for providing infrastructural facilities and learning resources are considered important since AI initiatives can not be implemented without curricula materials and other facilities. Review of existing computer science studies to reflect AI contents or development of AI curriculum is pertinent to learning. According to a respondent (Teacher 5), “one of the strategies [of integrating AI into schools] is to introduce it [AI] as a subject to develop a curriculum for it [AI] and it as a subject that students can choose from...” The call for strategic policies targeted at AI education for school’s students is central to the advancement of AI for K-12 initiatives including research evidence suggesting the feasibility of teaching AI to young students. Teaching AI through special programs created through out-of-school learning and field trips are considered useful approaches. The adoption of innovative pedagogical strategies was identified as critical to teaching and learning AI.

5. Discussion

Since AI has now been considered an important subject to be integrated into the K-12 context, it is imperative that we explore factors that will contribute to its effective implementation. Important considerations for promoting AI agenda in schools include understanding how different education stakeholders regard the idea as well as their dispositions and suggestions. Based on the results of our data analysis, this section will reflect on the findings along the lines of our research questions.

5.1. Stakeholders’ conceptions of AI and priorities for inclusion in the formal curriculum

Our findings indicate different conceptions of AI and reasons why AI should be considered as a subject for school curriculum. With regards to conceptions, AI is seen as super cognitive technology, assistive technology, and everyday computer technology. These ideas including how different stakeholders conceive AI resonates with common beliefs of what AI can or can not do. Even though the views of our participants indicate that AI exhibit human-like intelligence and can assist in task automation, none of their expressions suggests they know limitations of the emerging technology. For instance, under the theme “everyday computer technology,” some examples enumerated likened AI to any other technology. This misconception about AI is consistent with the study of Sanusi et al. [18] which reveals that students describe AI as any other technology before an intervention program. This exposition is a pointer to why awareness programs and developing AI education programs are necessary.

Regarding why AI should be considered a priority in schools, all the stakeholders believe it is because of its future relevance, societal development, global benefits, career choices and educational and skill development including the increasing influence and popularity of AI. These reasons linked to why AI should be incorporated into compulsory education including high school system are consistent with past research. For instance, the proponents of Five Big Ideas of AI [2], a framework that has been adopted globally to implement AI education in schools highlighted skill development and preparation of future AI related careers as a basis for teaching AI in schools. In addition, the increasing proliferation of AI applications and their use across different sectors and fields has been linked to the call for promoting AI to young learners [38]. Overall, introducing AI concepts to students at an early age has been reported to contribute to personal, professional, and societal development [2,39,40]. With regards to personal development, studies have shown that teaching AI to young students influences their problem-solving skills, critical thinking skills, and building students’ mental models [41]. As for professional development, students learning about AI prepares them for future learning, thereby providing them with foundational skills to build on as they progress to HEI institutions. For example, students’ familiarity with AI contents within K-12 levels will assist them in learning the advance version of the concepts in HEI AI course. This will be relevant especially that researchers are still exploring ways to effectively teach AI to students in HEI classes [42]. The early exposure of students to how AI operates will inspire their future career and make them career ready. Regarding societal development, it is believed that students learning AI early in life would allow them to see how AI could be used to specific solve societal problems. This opinion has also been supported by recent research that linked social good as an important factor for students and teachers to learn and teach AI in schools respectively.

5.2. Stakeholders’ concerns regarding teaching AI in schools

This study identifies psychological factors, policy issues, infrastructure, competence, and personnel as common concerns shared by all the three categories of participants. In addition to the earlier factors, the policymakers are also concerned by body of evidence to proof the feasibility of AI education programs for the young learners. Teachers are troubled with job loss, equity issues and lack of awareness of such initiatives among the general public. Students are specifically considering how to address the issue of ethics. Our findings are consistent with existing research. For instance, past research (e.g., Chai et al., 2023; [7, 40]) asserts that teachers and students’ psychological factors (e.g. attitude, readiness, anxiety, perceived usefulness) contributes to the successful implementation of AI in schools. The policy concerns raised is in tandem with Sanusi et al.’s [43] argument that implementing new subject requires policy review to meet the needs of the society. It also

consistent with the call for national AI strategic policies that ensure incorporation of AI in the early stages of school system [44]. Competence could be linked to the expertise the teachers have to lead the discussion about AI in the classroom as well as students' competence in learning the new concept. Studies have explored the role of students' competence in learning AI ([9,43]a) with the revelation that collaborative learning and cultural competence among others are significant in supporting students to learn AI. With respect to educators, scholars have argued that learning about AI in schools cannot be a success without providing teachers the pedagogical content knowledge including the technical knowledge which relates to their competence [45]. Personnel means the educators that will facilitate the learning of AI in classroom. Educators who are teach AI to students has been a concern as reported in several research papers which has led to the call for professional development opportunities and creation of teacher education programs [4,17].

Policymakers raised concerns about body of evidence to show that AI can be learned within the compulsory schooling stage. This concern is considered relevant since there are paucity of research on learning AI within the K-12 education in the African region [46,47]. This finding is an indication that more research should be conducted on the subject within the developing economy as the insights has implications for policy and practices. Teachers concern about job loss is consistent with earlier studies (e.g., [48]) that indicates teachers express anxiety about the AI's impact on employment rates. Research has established that regardless the automation, and technological revolution that comes with AI, teachers' role, and values they provide will continue to have impact on learning [20]. Teachers fears regarding job loss can be addressed with continual training about the use of AI and learning how AI works. Equity is another key concern raised by the teachers. The teachers are concerned that learning about these new concepts may be limited to urban areas and private schools with more resources. This concern is connected to the contextual peculiarity of the participants such that private schools are perceived to have more learning resources than public schools. Awareness that AI is being considered as a subject for young learners constitute a concern for teachers such that policymakers, program, and curriculum designers may not consider it to be adopted as a subject if they are not aware. This could account for why the current computer studies curriculum in the study context does not have AI related topics to be discussed in schools [20]. Lastly, ethical issues emerged from the students' point of view. Ethical implications have been considered critical to learning AI in recent times has it provides the opportunity to see the value of the emerging technology for our lives and the society. Research has shown that learning about ethical amplifies students' interest in learning about AI [49].

5.3. Stakeholders' opinion on support required to implement AI in schools

Our findings indicate that by instituting teacher education programs on AI, creating partnerships & collaborations, acquiring funding for AI initiatives, making infrastructural facility available, developing curriculum, and learning tools AI can be implemented in schools. In addition to the common themes from the participants, policymakers believe enacting strategic policies and research reports on AI learning are necessary. While teachers also believe that special programs for promoting AI in schools could be a promising approach, both teachers and students consider pedagogical strategies critical to learning AI. These findings validate the results of existing research. For instance, scholars have argued that teacher education is key to successful integration of AI education into the school system [50,51]. Our findings underscore the need to create opportunities for developing preservice teachers AI literacy to prepare them for future teaching practice for AI to gain currency in schools. Creating partnerships and collaboration with AI companies, schools and higher education institutions is considered important to push AI in school's agenda. Funding to enable easy access to learning resources and materials are key. Curriculum materials and learning tools

were also raised as vital elements. The importance of curriculum and tools for learning AI cannot be overemphasized, which has been shown with different versions that currently exist. Curricula materials targeted at various grade levels have been created including several AI learning tools as well. For example, Popbot was developed to introduce AI to children at early childhood education [52], AI ethics curriculum was targeted at middle school students [53] and AI curriculum for high school students [54]. Different learning tools also exist that have been reported to be effective in learning AI concepts. Such tools include Google Teachable Machine [55] for teaching supervised learning concepts, DoodleIt for teaching how convolutional neural networks work [38] among others. Most of these tools and curricula materials are open access and can be leveraged in the developing countries to learn about AI.

Policymakers' opinion about enacting strategic policies suggests the possibility of considering inclusion of AI in schools' system as a part of national AI policy strategies. The suggestion that research reports on the efficacy of teaching AI lessons to young learners is a positive indication. While evidence continues to build up on students learning of AI concepts, they are mostly in the developed contexts which necessitate that effort should be exert on building evidence of students and teachers learning of AI within the African context. Teachers suggested the design of special programs for popularizing AI in schools. This suggestion appears relevant because the concept is new which demands that novel initiatives should be introduced. The teacher suggested programs like out-of-school learning forums including field trips which have proven to be effective in promoting STEM initiatives to young learners [18,39]. Innovative pedagogical strategies also emerged as recommendations from teachers and students with regard to how to effectively introduce AI in K-12 education. This finding is in tandem with existing results which focus on how to teach the concept of AI to students [56,57]. These studies have highlighted how different novel approaches such as code-sign, participatory and designed oriented pedagogical strategies are useful in learning AI among young learners.

6. Conclusion, limitation and future research

This study investigates education stakeholders' views on how AI education can be implemented in schools. Our research specifically considered the thoughts of policymakers, teachers and students using a semi-structured set of questions. We interviewed 21 different participants at different times that met our inclusion criteria via the synchronous Zoom platform. The thematic analysis of the participants' data revealed how they think of AI, why AI education should be considered, what the concerns of AI integration are and how AI can be effectively implemented in schools. We anticipate that the outcome of this project could contribute to a comprehensive framework to be considered in ensuring the implementation of AI education in schools, especially in Nigeria or developing regions of Africa.

We identified several limitations in our study despite the useful findings. First, our study did not consider the opinion of K-12 students who would be the primary recipient of AI knowledge. Understanding the young students' perspectives is valuable considering the fact that students are entitled to participate in the discussion of topics relevant to their learning [43,58]. Future research should examine K-12 students' perspectives on AI with regards to the conceptions, including what they already know about the concept, to uncover how they can be supported to learn AI. Second, the use of a qualitative approach, small sample size and gender imbalance constitute a limitation. Even though our approach provided rich information for developing AI education in the region, using a mixed method research (using quantitative and qualitative) and having a large sample size would yield more insights. Future work should consider the use of mixed methods and large sample size including AI experts and practitioners. Third, our study participants combined the opinions of three different populations, which should be the study's strength. However, there are varying numbers of participants

in each population. In addition, this study does not provide a thick description of participants' demography including their familiarity and experience with AI. Fourth, our investigation is limited to Nigeria, which is an indication that the transferability of our findings to different African contexts should be treated with caution. Though African countries may share similar features, the continent is not monolithic – there are different countries with different AI needs and preferences [59]. Future researchers should explore different education stakeholders, including NGO and AI firms across different countries, to be able to address concerns and needs peculiar to different contexts.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Interview Questions Policymakers

1. Are you familiar with the term, Artificial Intelligence?
2. How would you describe AI in your own words?
3. With the recent call for AI inclusion as part of school subjects, what is your opinion as a policy maker?
4. How would you describe the relevance of teaching AI in schools and what are the implications?
5. What strategies could be adopted to integrate AI into our school system?
6. Do you consider AI inclusion in formal curriculum a priority? If yes or no, why?
7. What concerns do you have with regards to teaching AI in schools?
8. How can the government be supported to develop AI literacy in our school system?
9. Would you like to add something besides the questions asked already?

Teachers

1. Are you familiar with the term, Artificial Intelligence?
2. How would you describe AI in your own words?
3. With the recent call for AI inclusion as part of school subjects, what is your opinion as an educator?
4. How would you describe the relevance of teaching AI in schools and what are the implications?
5. What strategies could be adopted to integrate AI into our school system?
6. Do you consider AI inclusion in formal curriculum a priority? If yes or no, why?
7. What concerns do you have with regards to teaching AI in schools?
8. How can HEIs be supported to develop AI literacy in our school system?
9. Would you like to add something besides the questions asked already?

Students

1. Are you familiar with the term, Artificial Intelligence?
2. How would you describe AI in your own words?
3. With the recent call for AI inclusion as part of school subjects, what is your opinion as a university student?
4. How would you describe the relevance of teaching AI in schools and what are the implications?
5. Do you consider AI inclusion in formal curriculum a priority? If yes or no, why?
6. Do you believe that if you had been taught AI in school it would have prepared you for your present course of study? If YES, how? If No, why?
7. Have you taken an AI or ML course as part of your program? Can you imagine how AI knowledge would have helped?
8. What concerns do you have with regards to learning AI in schools?
9. What strategies could be adopted to integrate AI into the school system? e.g. game-based learning?
10. How can students be supported to develop AI literacy in our school system?

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