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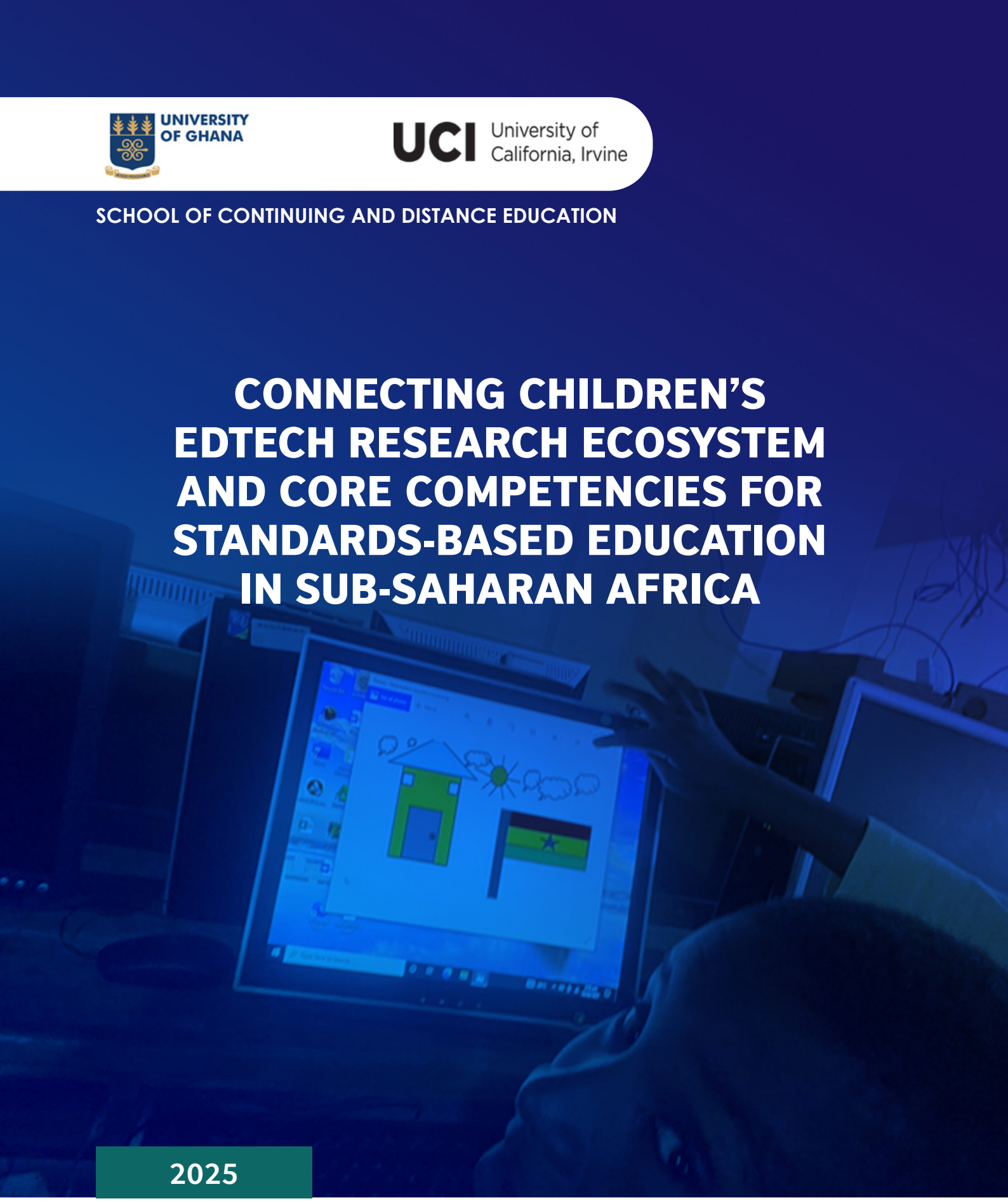
CONNECTING CHILDREN'S EDTECH RESEARCH ECOSYSTEM AND CORE COMPETENCIES FOR STANDARDS-BASED EDUCATION IN SUB-SAHARAN AFRICA



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Connecting the EdTech Research Eco*System

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CONNECTING CHILDREN'S EDTECH RESEARCH ECOSYSTEM AND CORE COMPETENCIES FOR STANDARDS-BASED EDUCATION IN SUB-SAHARAN AFRICA

Technical report presented to the CERES global partners

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ABSTRACT

Abstract

Despite advanced digital innovations revolutionising many sectors of nations' economies, the 2019 pandemic forced the closure of schools with few antidotes to meeting children's developmental needs. As the global community is taking stock of school disruptions occasioned by natural disasters, wars, and pandemics today, discourse on quality learning outcomes for children has gained the attention of global partners in education. While the disruptions showed the unpreparedness of education systems to adopt digital resources against exogenous factors globally, they also highlighted the non-resilience of early grade systems to deploy creative pedagogies for children's global competencies in many countries in the global majority. Teachers and children's digital resilience are imperative for sustainable educational outcomes in early-grade classrooms. Still, many digital interventions introduced to support continuous education focused on adults with minimal attention to children's developmental psychology needs, accessible education, a widening digital divide, and global skills. Evidence-based and brain science-inspired digital learning grounded interventions involving edtech solutions are needed to support inquiry-based pedagogy in schools. Hence, the research explored how children's digital ecosystem impacts children's 21st-century skills in post-pandemic classrooms in Sub-Saharan Africa using a mixed-methods research design, including participatory coding to generate observation data from 102 children's classrooms and teacher surveys across five regions in Ghana. Checklist items were coded and visualised alongside descriptive statistics, while Kruskal-Wallis, logistic regression, t-test, and ANOVA were used to test six hypotheses for evidence-based decision making. The results showed a post-pandemic digital ecosystem characterised by laboratory settings for children learning 'about' computers instead of learning 'with' computers, as access favoured private than public schools. Similarly, access had no significant impact on children's inquiry-based learning, global skills, and inclusive didactics, which is partly attributed to low teacher digital adoption skills for online instruction. The study concluded that despite the adoption of standards-based learning reforms for some Sub-Saharan African education systems requiring a digital integration framework, digital disparities exist in learning environments as investment in computers is yet to influence careers and core competencies, and facilitators are slowly applying technology and pedagogical content knowledge to problem-based learning and online education simulations. Hence, should there be a reemergence of a pandemic, the weak children's edtech ecosystems will compel education systems' shutdown, and educators are yet to translate access to online and multimedia content to elicit Sub-Saharan Africa learners' 21st-century skills. Implications of the primary results are discussed for edtech policy, and teacher professional development recommendations are made.

Keywords: digital ecosystem, global competencies, inquiry-based learning, learning loss, accessible education, teachers' digital skills, resilient schools; Ghana, Sub-Saharan Africa

List of Abbreviations

CBC	Competency-Based Curriculum
CERES	Connecting an edtech research ecosystem
GES	Ghana Education Service
JF	Jacobs Foundation
MoE	Ministry of Education
NaCCA	National Council for Curriculum and Assessment
UCI	University of California, Irvine
UG	University of Ghana


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Stiff and Soft
Kumi has new brush.
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It is strong.
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Introduction

Vestiges of the 2019 pandemic have deepened the global learning crisis for Sub-Saharan Africa. According to the World Bank (2024), the international community needs to deal with high underachievement in global skills, as many may lack basic literacy, numeracy, critical thinking, and problem-solving skills, with widening gender and social inequalities. Characterised by limited resources and school infrastructure, many schools in Sub-Saharan Africa were adversely affected, with over 62 million children out of school before the pandemic. For most African countries, children were out of school for nearly nine months due to a lack of digital tools to navigate the COVID-19 social distancing protocols, causing learning loss in global competencies for the 21st-century career trajectories.

Digital experiences had become a standard part of children's learning, playing, and socialising before the COVID-19 pandemic. However, the unexpected happened in March 2020 when youngsters worldwide were denied opportunities to socialise with peers and interact with their teachers overnight to prevent the spread of the Omicron virus. Out of their classrooms, some were engaged in a variety of online spaces to learn with limited digital resources, as teachers were unprepared. Evidence suggests that young people represent 1 in 3 internet users globally. Yet, online spaces and tools are often not designed to offer children the support and opportunities for learning that they need for their career growth. As school doors have been reopened and children reunited with teachers and friends, most will continue to learn and socialise online, with questions about digital ecosystem's disparities and education quality likely to support children's global competencies in the 21st century remaining.

Hence, education stakeholders seek creative solutions to children's developmental needs, including neurodiversity, global skills, and personalised learning. Learners are exposed to information-rich environments spurred by hyper-connectivity and convergence media. Amidst frequent curriculum reforms, children are in a quagmire of memorising content standards for no apparent reason, rather than examinations in place of inquiry-based learning for age-appropriate differentiation, equity and social inclusion outcomes. For school systems in the Global South, curriculum changes have focused on structural reforms in years and subjects, with minimal attention on dialogic and critical consciousness required for the Fourth Industrial Revolution. Textbook-based instruction subduing core competencies, including collaboration and global citizenship, communication and personal development, critical thinking, problem-solving, sustainability, and ethical standards. Facilitators tend to transpose objective-based assessment characterised by textbook testing while citing increased workloads from additional subject teaching and crowded classrooms (Anapey, 2025). Therefore,

this research explored children's digital access, accessible education needs, and global skills in Ghana's standards-based education system to inform post-COVID-19 education interventions in Sub-Saharan Africa.

Globally, successful curriculum implementation depends on teachers' professional experiences in content standards delivery, assessment, and extracurricular activities. While teachers' standards varied from advanced to third-world nations, being abreast with digital integration and pedagogical knowledge that supports children's development should be universal. However, should the world witness another pandemic of 2020 magnitude with the closure of educational systems, a poignant question remains about teacher readiness and adaptability to digital innovations supporting children's learning goals in the Global South. Indeed, health scares are challenging for educational systems. Schools need to be resilient and withstand global shocks likely to affect children's learning in advanced and developing countries. While nations in the Global North are heavily dependent on generative AI tools and adapting efficiently to adolescents' learning needs during pandemics, their counterparts in the global south are lagging in deploying educational technology tools in children's learning environments. Above all, Children in Africa continue to experience widening digital divides, school dropouts, and many have lost contact with teachers and peers during the COVID pandemic.

From a developmental psychology perspective, typical and atypical children are instinctively wired to explore their built and natural environments irrespective of genetics, psychological or environmental developmental delays (Cade, 2023). Hence, valuable developmental stage learnings must be accounted for by development partners, as school closures have a developmental delay in pupils' academic and career trajectories.

The lifting of social distancing protocols has been a relief to all globally, with education systems in third-world countries returning to the 'new normal' school environments, with teacher-led interactions resuming for children and minimal digital adoption due to resource and teacher professionalism constraints in the pandemic era. During school disruptions, the global community witnessed minimal interventions targeting age-appropriate edtech tools for children. In some jurisdictions, computer resources were available.

Yet, teachers' low digital skills for online instruction in early grade learners' environments were obvious, irrespective of recent curriculum reforms adopting standards-based curriculum. Pre-tertiary reforms in Ghana and Sierra Leone demand teachers and pupils' digital literacy and other 21st-century skills as key performance indicators (Ministry of Basic and Senior Secondary Education [MBSSE], 2020; National Council for Curriculum and Assessment [NaCCA], 2018): brilliant propositions and adoption of competency-based curriculum targeting children's global skills. However, technology integration requires more than political sloganeering, as the pandemics expose the disconnect between policy advocacy and impact measures for most developing countries. Ames (2019) highlights the lacunae in edtech deployment and weak teacher capacity impacting Latin American schools' One Laptop per Child project (OLPC). While Ames' account about MIT gurus' ambitions for computers replacing teachers as children code and learn mathematics with their laptops was a rhetoric rather than a reality for many.

The OLPC project represents a test case for education partners' intentionality about teacher technology professional development to support content application to real-world scenario building. Prudence could have it that education governance should increase digital media access to school teaching and learning. On the other hand, emerging generative AI tools are widening Africa's digital divide with low household ICT ownership. In Ghana, nations experience low digital skills (National Communications Authority [NCA], 2020). Indeed, access is imperative for reducing gendered technological divides. Still, inadequate infrastructural funding continues to deepen digital gaps for many third-world countries, as teacher technology pedagogical content knowledge (TPACK) ought to be supported in marginalised societies.

Despite the growing popularity of digital tools in education, there remains a notable absence of systematic evidence regarding their effective integration into children's creative learning pedagogy in developing countries. In the face of inadequate funding to support children's learning, Sub-Saharan Africa's schools require an exploratory approach to generating baseline data for learning gap identification. Therefore, the CERES (Connecting the EdTech Research Ecosystem) is a global network of transdisciplinary researchers and scholars exploring country's educational technology ecosystem and impact on children's quality education in the post-COVID era. Specifically, Ghana's team focuses on new and widening digital divides, educational access, disability, gender equity, social inclusion, creative pedagogy, digital algorithms, learner diagnostics supporting children's career trajectories, and a standards-based education outcomes. Funded by the Jacobs Foundation in partnership with the University of California, Irvine, and the University of Ghana, the research team focused on evidence at the heart of education policy and pedagogical practice for foundational learning in Global South schools. The project also bridged the research gap in children core competencies and instructional technology access, to improve psycho-developmental needs in learning contexts. Adoption of diagnostic data for innovative pedagogy, connecting content standards to real-world problem solving, and children's active participation in the Digital Age were explored as part of evidence generation to solve inquiry-based learning gaps in marginalised schools.

As Post-COVID narratives are also igniting debates about access, inclusion, differentiation, and scaffolding for differently abled learners with increased public school enrolment, child education science is required to connect emerging digital tools to learning goals. Models are required to deconstruct accessible education themes in the context of Edtech innovations for children today as gender, equity, and social inclusion (GESI) are dominant themes in tech integration in the Global South classroom.

Hence, child education science and predictive modelling would be essential for simulating resilient school systems against disruption, and quality learning for children from marginalised communities. Expanding education for all and quality learning under Sustainable Development Goal 4 without commensurate digital inputs can strain the limited educational infrastructure in developing countries. Urgent attention is required to connect the educational technology ecosystem (CERES) for children through rigorous scientific evidence generation. This will impact digital innovations for algorithmic skills within the context of standards-based curriculum reforms in Sub-Saharan Africa.

The overarching questions for the CERES project include the influence of emerging digital innovations and online tools in schools as children prepare for 21st-century careers.

Deepening the participatory approaches that connect the edtech research ecosystem also informed the current study's goals addressing the widening digital divide at the foundational level. As the global community continues to embrace AI tools in preparedness for the reemergence of future pandemics, lack of investment in digital resources for children's education in the Global South will worsen their already low ICT skills.

Teacher professional development (TPD) interventions have yet to achieve the technology pedagogical content knowledge (TPACK) for children in marginalised communities.

The lack of national technology standards for teachers and students (NTS.t/NTS.s) from standards-based education frameworks for some Sub-Saharan African education systems are impacting competency-based assessment, 3% shared device ownership for Ghana's households ([NCA, 2020) is imperative for children's global skills in the Age of AI. While teacher awareness of learner-centred approaches is high, their success stories have yet to be documented in learning contexts. National examinations are structured around content standards memorisation in developing countries.

Translational science would be needed to implement dialogic pedagogies connecting content standards with real-world problem-solving and measuring global skills grounded in learning theories, including affective, cognitive, and psychomotor skills for resilient school systems for citizens in the global majority.

Purpose of the Study

The CERES project explored children's digital ecosystem and inquiry-based learning experiences to generate empirical evidence for knowledge translation addressing the global learning crisis, the growing digital gaps, inclusive education, gender equity and social inclusion (GESI) for children from a Global South perspective. While impacting teachers' creative pedagogy, professionalism, deepening digital learning, children's cognitive and developmental outcomess will be impacted. Instructional design, and multimedia tools for deep learning inspired by emerging technologies and industry partnerships would be addressed. Edtech partners can benefit from knowledge translation in product design supporting children's digital personalisation backed by knowledge domain from human-computer interaction (HCI).

The research findings will also bridge the product gaps in adolescents' edtech adoption, while providing validated matrices informing early childhood education in marginalised communities. Even rewarding will be an admission that learning scientists, including human-computer interaction experts, educational psychologists, instructional designers, and curriculum developers, translating evidence to practice and ameliorating children's learning loss. Therefore, the research impact will improve key performance indicators for standards-based curriculum reforms for Sub-Saharan African nations informed by real-world data modelling involving participatory and codesign approaches social justice advocacy culture for children. Theory of change from child education scientists would equally leverage digital tools to advance personalised learning platforms for

the next generation of scientists using Indigenous intervention and AI tools for key population persons.

Research Questions

The research questions were guided by CERES themes, including digital access for neurodiverse instruction, algorithmic skills and interventions informing new product design for children, inquiry-based pedagogy and developmental psychology practices impacting brain science-inspired for early grade learning:

i. How is digital access impacting children's pandemic readiness in Global South schools?

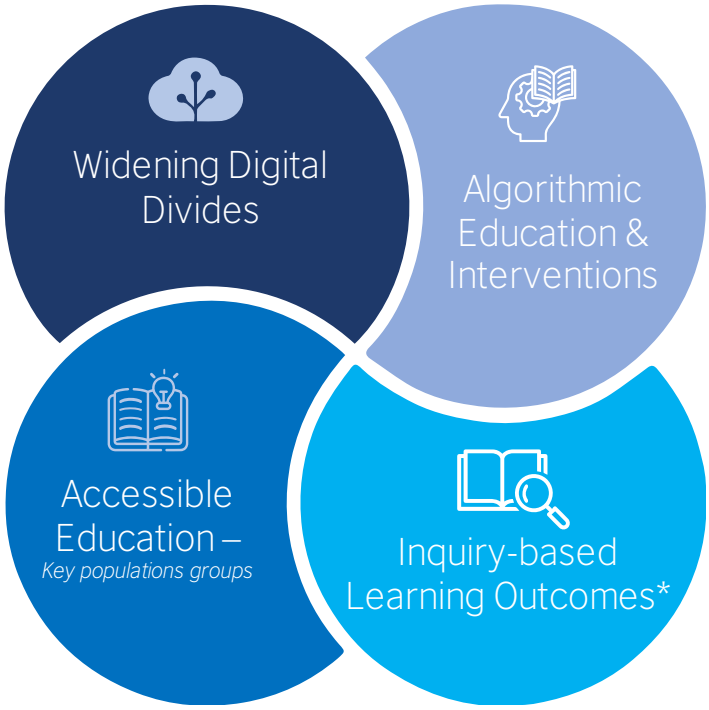
ii. Which assistive technology devices are impacting quality and accessible education for neurodiverse children in Africa's foundational classrooms?

iii. How are teachers' digital adoptions influencing children's inquiry-based learning and global skills in the post-pandemic era?

iv. Which online instruction measures are supporting children's education for future pandemics mitigation in Africa's marginalised schools?

v. What theory of change is required for schools targeting children's global skills and sustainable school structures?

CERES Research Areas in Ghana



Literature Review

Understanding the pandemic's impact on children's 21st-century skills, including mental health resilience, personal development, communication, collaboration, global citizenship, ethical standards, and environmental sustainability must engage learning scientists' attention. Also, COVID-19's disruption to school systems globally has heightened global partners' interventions in education to build resilient education systems through generative AI tools. Therefore, evidence-based decision-making about emerging digital ecosystems for quality and sustainable schools during pandemics is imperative for countries in the global majority. With dwindling education financing, unpredictable global health systems, climate change, natural disasters, and wars, causing children's learning loss. However, digital ecosystem research in Sub-Saharan Africa are dominated by qualitative views (Anapey & Aheto, 2022; National Communications Authority [NCA], 2020),.Moreso, little is known from participatory and co-design research approaches and learning scientists sharing scholar-practitioner knowledge on assessing the digital availability, utilisation, and adoption in Africa's early grade schools. Observation, interviews, and evaluative research would highlight the effectiveness of edtech tools in supporting children's learning. Hence, the report shares extant literature guiding engagements, research design, analysis, and interpretation of empirical data supporting evidence generation, and recommendations towards resilient educational delivery targeting children's global skills and reemergence of pandemics in digital infrastructural marginalised communities.

Digital Innovations and Pandemic Preparedness

The introduction of ICT subjects in the standards-based curriculum reform emphasised digital skills and children's 21st-century skills (NaCCA, 2018). While the reform has raised high awareness about computers for children's learning, the minimal integration of teachers' integration litracy in classrooms remains a challenge during COVID-19. With limited digital applications and resource constraints, the pandemic's disruption to educational systems has adversely affected children's learning in Sub-Saharan Africa. While alternative teaching techniques such as television, radio, and the internet were employed to mitigate the pandemic's' adverse effects (Agbe & Sefa-Nyarko, 2020), these interventions focused on the tertiary education sector at the neglect of on foundational learning in marginalised communities.

E-learning interventions in schools is not a novel concept in Africa (Awidi, 2008; Dadzie, 2009) but e-learning initiatives lacked significant advancements in in schools (Kotoua et al., 2015). Unavailability of digital devices, electricity and, hyperconnectivity to facilitate quality learning goals (Addae et al., 2022). Analogue televisions continue to dominate the educational technology

tools in schools (Amjad, 2021) for urban and rural children. Disparities exists between public and private schools. for most households, shared mobile devices guaranted access in the digital age (NCA, 2020). Private school children in urban communities used virtual platforms such as Zoom, Google Classrooms, WhatsApp, and YouTube, while low-cost private and public schools were on the fringes of learning. Traditional media and television tutorials provided by the government, with no interactivity between facilitators and learners. Limited progress in technology integration and during the pandemic in developing countries has been observed (Anaafo et al., 2021; Patel & Shah, 2020). Economic, gaps in e-learning. Williamson et al. (2020) surmised that the pandemic readiness must factor digital tools into educational systems in third-world countries.

Arguably, the emergence of Web 2.0 has greatly facilitated learning management systems' capacity to mimic instructional cycles across the lifespan, where learners submit assignments to teachers, using synchronous and asynchronous instructional approaches are ubiquitous today. However, parents and educators' digital competencies are needed to leverage emerging technologies for children's global competencies. Unfortunately, in-person teaching with teachers examining regurgitated content for children has characterised early grade education in Sub-Saharan Africa. Most teachers are yet to integrate edtech solutions to facilitate inquiry-based learning for children. Therefore, stakeholder assessment of how computers have supported creative pedagogy in Global South Schools will be essential for quality education outcomes after post-COVID-19.

Against the backdrop of policy frameworks, Ghana has also experimented with many digital projects for school students and teachers. Some of these projects followed the Latin America case of One-Laptop Per Child (OLPC). Championed by Nicholas Negroponte, the OLPC initiative, was underpinned by constructivists' learning principles (Ames, 2019). While OLPC initiatives have been celebrated as avenues to bridge the digital divides between the rich and poor communities also faced integrationn challenges, including a lack of teacher capacity to adapt software and hardware to support quality learning outcomes for children. The considerable investments in these technologies often recede into oblivion as educational institutions cannot measure the return on investment. Computer enthusiasts continue to extol the charisma of computers, as some even profess that they will replace teachers in the classroom. However, Ames christened OLPC projects across Latin American region as social imaginaries and Trojan horses that hijacked content deliveries. Imple, entaiton was characterised by chaos and technical hitches, as many teachers were frustrated. Digital tools are not impacting integration in many schools today either. For instance, under the 1-Teacher-1 Laptop programme, 17,000 teachers have received computers in Ghana's public basic schools (Abubakar, 2024). Howeverr, competency-based curriculum outcomes.

When instructional strategies focus on regurgitating events, procedures, and historical facts, learners are disconnected from relating content to real-world problem-solving and future career development staggers. Succinctly put by Jonassen (2004), children learn strands for no apparent reason and are overwhelmed with multiple subjects, leaving teachers disconnected from quality teaching. Conflicting is the scenario where teachers have been oriented to deliver

content using classical learning theories such as the stimulus-response approach, grounded in behaviourist theory, with minimal innovation, guiding children to construct knowledge from their social and built environments. While education theories are guiding principles for knowledge exploration, overreliance on teacher-centered models without digital integration principles is a recipe for disaster in the 21st century. Admittedly, learning science scholar-practitioners are required to advance digital integration models in children's classrooms towards achieving Education for Sustainable Development outcomes (Anapey, 2024). Equally, teacher professional development interventions including brain science, developmental psychology, mental health, counselling, competency-based instructional design, online learning, multimedia skills, creative pedagogy, and dialogic learning outcomes are imparative for digital innovations and pandemic preparedness for Global South.

Digital Ecosystem and Mainstream Education

The power of the microchip to store and retrieve large volumes of data has never ceased to amaze humanity, compelling Learning Scientists to extol the place of computers in schools today. With the tutorial and simulation features of computers, many postulated that it would replace teachers in the classroom by providing freedom to surf the World Wide Web for unlimited content and children connecting with peers and communities of learners around the globe. However, validation of such futuristic views remains hazy on the fringes of vestiges of the pandemics, wars, and natural disasters disrupting educational systems. Increasing learning loss, and school dropout rates globally (UNESCO, 2023) are evidence of inability reflections of digital ecosystem in education.

Besides, translating digital access into deep learning needs of children has received minimal attention during the pandemic, significantly impacting their inquiry-based learning and 21st-century skills. At the same time, the kaleidoscopic nature of human activities is a given; targeted discourse on Sustainable Development Goal 4 on education quality should be guided by knowledge translation to inform teacher professionalism for mainstream education in Sub-Saharan Africa. Therefore, we provide a scoping review of relevant literature on digital ecosystems, accessible education, and competency-based curriculum reforms to guide evidence-based pedagogical practices and policy advocacy for foundational learning in marginalised communities.

By far, computers support children's inquiry-based learning goals such as interacting with content standards using questioning skills, addressing pedagogical principles of scaffolding, differentiation, inclusion, learner-centred, and collaborative skills. The power of computers can support teachers to account for education cross-cutting themes, including gender equity and social inclusion, language (L1 and L2) development, peace building and conflict transformation. Digital tools are enablers of students' entrepreneurship skills. while focusing on affective, psychomotor, leadership, resilience, respect for evidence generation for decision making. Higher-order cognition is supported in mainstream classrooms when students are exposed to computers.

Historically, computers made a triumphant entry into schools decades ago with varying outcomes. While the advanced societies have progressed with integration that involves teaching

with computers, developing nations are saddled with teaching about computers, with learners busily memorising parts of electronic devices to pass national examinations. Lack of teacher capacity to adopt digital tools can be partly attributed to the floundering of digital initiatives in developing countries, as established in the one-laptop-per-child projects in Latin America (Ames, 2019). Notwithstanding challenges of digital application in early childhood education, curriculum reforms continue to acknowledge imperatives of twenty-first-century learning outcomes in mainstream classrooms (Ministry of Education [MoE], 2015; National Council for Curriculum and Assessment [NaCCA], 2018).

Ghana currently adopts a standards-based education system that classifies basic education from age 6-17, focusing on competency-based learning outcomes, including digital literacy, critical thinking and problem-solving, global citizenship, personal development, and communication skills. Two years of early childhood education (ECE) precede basic education for children with a curriculum framework developed by the National Council for Curriculum and Assessment (NaCCA, 2018) under the Ministry of Education. However, children's digital learning preceded current curriculum reforms for Ghana with the 2003 Information and Communication Technology for Accelerated Development policy (Government of Ghana, 2003) to guide computer integration in all sectors of the economy, including mainstream education. The policy imperatives equally spurred curriculum discourse, such as the 2007 reform that introduced ICT as a subject on schools' timetables, and the 2018 NaCCA curriculum mandating children's use of digital resources to develop 21st-century skills.

Efficient use of digital tools must be centred on mainstreaming policy of inclusion for addressing children's global learning for Sub-Saharan African schools. Evidence suggests low technology pedagogical content knowledge remains challenging in Africa's early grade schools after the 2019 gandemic (Anapey & Adamba, 2025). Testing teacher professionalism is an excellent intervention supporting quality curriculum delivery in Ghana's schools (see National Teaching Council, 2021) complimented the education sector strategic plan for teacher and pupils' digital skills (Ministry of Education [MoE], 2018), and the digital tools integration into children's learning outcomes at the pre-tertiary level (National Communications Authority [NCA], 2020).

Ghana's education sector policies on inclusive education provides for accessible education for all towards realising Sustainable Development Goal 4 on quality learning (MoE 2013). While the policies are progressive, academic discourse about mixed school curriculum at the basic education level ignored clear plans for teacher pedagogical framework for inclusive learning. More deliterious to most inclusion ideals is objectives-based learning, compromising education for sustainability and competency-based learning outcomes in many Sub-Saharan African schools. Inclusive instructions gloss over indigenous knowledges. Solution to the mainstream education lies in Standards-based curriculum (SBC) with a unique learning framework guiding inquiry-based learning. Indeed, SBC demands teacher professionalism, technology pedagogical content knowledge (TPACK), authentic assessment, indigenous knowledges, and problem-based learning.

Digital integration is imperative for mainstreaming education. While the Centre for National Distance Learning has mandates to strengthened Ghana's pre-

tertiary education sector through open and distance learning modules mounted on a dedicated television channel (Tanye, 2017), teachers continue to deliver objective-based ddidactics that ignore diverse learning needs. Invariably, cognitive domain-oriented curricula pedagogy is synonymous with teacher-lead activities in many marginalised schools. Backed by learning sciences theories and edtech research, children's learning needs must be complemented by pedagogical principles and cross-cutting themes to achieve foundational learning outcomes in mainstream education. For developing countries, low-cost digital resources are characterising the edtech discourse, with teachers requiring integration competencies. For many Global South schools, the computer has assumed a charismatic and performative stature for third-world schools (Ames, 2019).

Despite curriculum reforms targeting children's 21st-century skills, five years of standards-based education evaluation reveal challenges associated with alternative assessments, multimedia designs, and inquiry-based learning required to support children's executive functioning (Table 1). Children's education in crowded classrooms is still lopsided regarding textbook administration and workbook activities. Teacher-learner interaction in dialogic learning, where learners question facts, events and processes, is essential for 21st-century skills. However, unfavourable learning environments compounded by the pandemic's disruption to learning are deepening underachievement in marginalised communities in Sub-Saharan Africa.

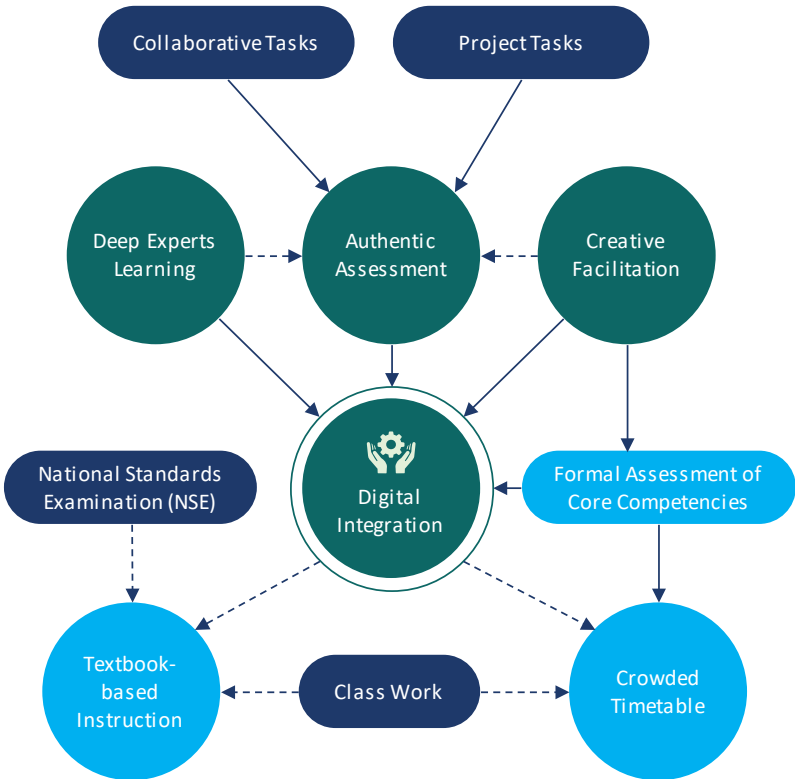


Figure 1. SBC reform practices in Anglophone West Africa (Source: Adapted from Anapey, 2024,)

Neurodiversity and Accessible Education in Africa' Early Grade Schools

Neurodiversity is often biologically defined, with many researchers ignoring sociocultural predictors. In the developmental science literature, atypical development has been characterised in neurodevelopmental conditions, including autism, as well as other learning disorders, leading to mental health challenges for individuals (Dwye, 2022). Dwye's view is informed by biological malformations in neurons or neurotransmitters rather than a perspective, belief, method, or cultural standpoint. It is essential to emphasise a significant difference between the neurodiversity paradigm and cultural adaptations for foundational learning needs. Also, Léon et al. (2023) broadened neurodiversity to include neurological and mental differences in humans while attributing neurological variations to inheritance rather than a cognitive deficit.

Biological conditions present impediments to children' deducation and must be addressed with technology tools. studies on neurodiversity characterised the concept from brain imaging, which show the differences between individual thinking pathways; thus, individuals who are neurotypical and those with neurodiversity (Clouder et al., 2020; Léon et al., 2023). Clouder et al (2020) simplified neurodiversity by positing that human brains are programmed very differently, and differences significantly impact human's thinking and learning ability. Neurodiversity is a condition that consists of lifelong conditions that are developed in one's lifetime (Léon et al., 2023) and children are not exception at the early grade level.

Note: Neurodiverse learners sometimes neglected in mainstream classrooms

According to Dwyer (2022), various types of neurodiversity, including brain injury, Attention Deficit Hyperactivity Disorder (ADHD), dyslexia, dyscalculia, intellectual disability, mental health, Autism Spectrum Disorder, and Tourette syndrome are common in learning environments. Also, Shields & Beversdorf (2020) Dysgraphia, Down syndrome, and chronic mental illnesses such as bipolar disorder, epilepsy, borderline personality disorder, anxiety, and depression. Broadly, neurodiversity, can be groiped as neurotypical and neurodivergent. Neurotypical humans are a set of standard or typical brain operations, behaviours, and standard processing required for daily interaction. Their brains function similarly to other humans'; however, scientific data shows that they function similarly to those of other humans. Neurotypicals typically develop life skills, including social or organisational skills, at the same pace as other humans their age (Sörös et al., 2019). In addition, neurotypicals have their brains wired to attain standard abilities common in other neurotypical individuals. These include tolerating sensory discomfort such as noise, easily adapting to new routines, remaining focused in class for extended periods, and developing an interest in various hobbies (Sörös et al., 2019).

Therefore, understanding such diversity are crucial assistive technology

training for teachers. Neurotypical humans are epistemically categorised under dominant groups who have the cognitive ability and profile to respond to established norms in society (Legault et al., 2021). On the contrary, Legault et al. (2021) characterised neurodivergent individuals as a category of humans who do not possess the cognitive power and profile to align with established norms, and they do not attain any benefit from mental capabilities like neurotypical humans. Neurodivergent and atypical humans are. According to studies, there are various ways that neurodivergence in a human is exhibited, ranging from moderate ways that are unnoticeable to more obvious actions that are highly noticeable by other humans in society (Legault et al., 2021).

Neurodiversity equally live with adullts at the workplace, among women and men, in film, and in the academic context. For instance, DeThorne & Searsmith (2021) conducted a study on autism and neurodiversity. with implications for school-based speech in high schools. However, speech-based pathologists in schools often encounter institutional constraints such as eligibility determination and individualised education processes not aligned with the neurodiversity paradigm.

While applied neurodiversity describes innate neurological conditions, it is not considered a health condition (Shields & Beversdorf, 2020). Unavailability of diagnostic data in schools tends to lead teachers wrong judgements with chilldren having difficulty applying skills, including gross motor control, reading, and number concepts. Difficulties in social skills, communication, action, and impulse control are sometimes missed by caregivers.

According to the United Nations (2023), Sustainable Development Goal 4 targets facilities and resources that are gender and disability friendly to provide safe, nonviolent, practical learning and inclusive learning environments for all. Inclusive education has imperative for economic growth in societies (Boyle et al., 2020). Consequently, international organisations and government bodies are implementing policies that seek to develop a suitable environment for individuals to attain knowledge and eventually, contribute to national development.

For instance, Slee (2018) established that inclusive education for students with special needs was plagued with diverse challenges, especially. Also, Lin & Gold (2017) discovered that 90 per cent of children with disabilities in the USA use assistive technologies for vision, hearing, movement, and communication. However, (Gokaydin et al., 2020), highlight technology for children with Autism spectrum disorder,

The absence of empirical data on edtech use in inclusive classrooms are impacing quality learning in developing nations.

Spiel et al. (2017) a study on the experiences of ASD focused on children's experience in basic schools with technologies such as AI–powered tools impacting inclusion targets, including children with dyslexia. social–emotional learning, personal, and academic development.

From the African context, Nana et al. (2023) established that it takes at least two years to diagnose a child with autism, ASD is a major neurodivergent condition that researchers explore despite the existence of other conditions like dyslexia, Tourette syndrome, and Down syndrome, amongst others receive minimal attention in the neurodiversity literature. Mensah & Hayfron-Acquah (2018) the paucity of empirical work

about autism children and assistive technology in Ghanaian schools.

Universal Design for Learning Principles and Inclusion

This study is underpinned by the Universal Design for Learning (UDL) propounded by David Rose and Anne Meyer, as a structured framework designed to assist children with disability (Roski et al., 2021). UDL involves designing curricula, technologies, and instructions to meet the various needs of all students in an academic environment, and incorporates additional aspects of learning. Processing data and developing an enhanced understanding of school data, such as executive functioning, organisational skills, progress monitoring capability, engaging in a learning space and self-assessing and personal reflection (Cumming & Rose, 2021). UDL has its foundation in Neuroscience, the mother of neurodiversity (Capp, 2018). Primarily, brain network is associated with UDL principle of learning, namely engagement (why humans learn), representation (what humans learn) and action and expression (how humans learn). With a perspective on how humans learn, the UDL principle establishes the development of necessary resources to assist individuals in education. Just as Spiel et al. (2017) asserted, technologies are relevant resources that can assist neurodivergent children in basic schools to attain a standard level of performance and eventually become part of the standard norms of society. Based on the UDL model, most researchers have encouraged teachers and educational technology developers to build assistive models that will enhance the learning capabilities of neurodivergent students in basic schools. Notwithstanding, UDL's application requires digital skills and little is known in the Ghanaian context. Based on the UDL model, this study provides insight and examination into the EdTech ecosystem for foundational learning in marginalised schools.

Socio-cultural practices are unfortunate sources of exclusion in the learning context (Ainscow, 2020), hence collaboration is required to redesign systems to accommodate diversity. Indeed, collective cultures intertwined with colonial identity in African school structures should be tackled in curriculum delivery as teachers apply UDL models in classrooms. Didactic approaches can better eliminate discretion alongside policy frameworks such as Ghana's Inclusive Education Policy (Ministry of Education, 2013) in the Digital Age. However, the extant inclusive literature is silent on teacher professional knowledge in applying the UDL in mainstream classrooms that elicits foundational core competencies in marginalised schools. Anapey et al. (2025) established three emerging constructs: teacher proactiveness in lesson design, inclusive knowledge, and learner variability indicators in Ghana's standards-based education system. Teachers' use of the English language has been higher for children in urban and peri-urban than rural schools. Also global skills development are likely to be observed for children in cities than in Indigenous African communities. such disparities are stagnant inclusive targets in Africa's post-pandemic classrooms.

Surely, the pen and paper-based national examination had served the purpose of person specifications, recruitment, and performance management for factory-based jobs in the industrial age without hindrance. Today's employment market demands multitalented adolescents with critical thinking and problem-solving skills, coding and programming knowledge, resilience and sustainability traits that

drive entrepreneurship for the Fourth Industrial Revolution. Hence, curriculum reforms targeting children must do more to connect strands to problem-based learning, while measuring global skills outlined in curriculum frameworks. Figure 2 illustrates an instructional design framework for teacher pedagogical knowledge sharing for developing children's 21st-century skills using UDL and differential assessment in a multimedia laboratory to support inclusive education policy in early childhood classrooms. Frameworks of children's assessment must be altered to accommodate competency curriculum for countries adopting standards-based education.

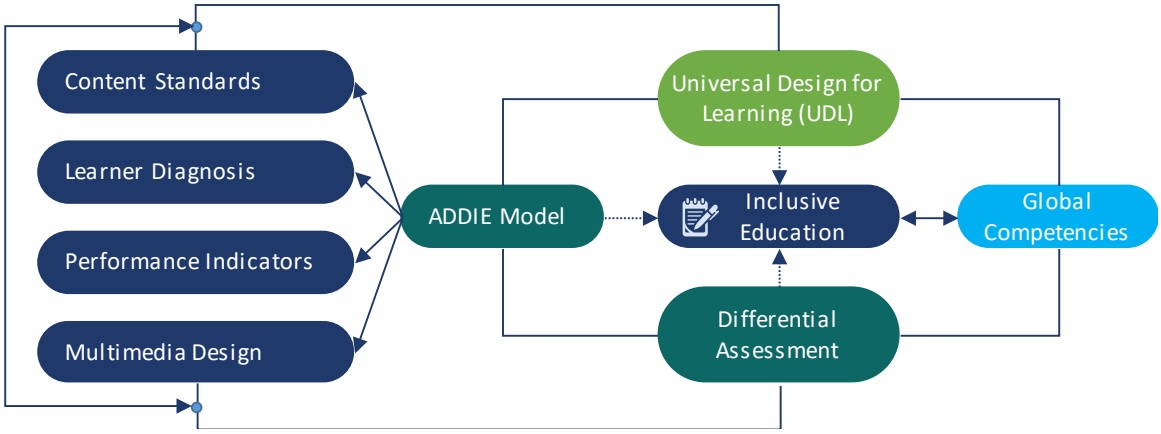


Figure 2. Emerging UDL and inclusive practices in Sub-Saharan African schools (Source: Adapted from Anapey et al., 2025)

COVID-19 exposed weaknesses in textbook-dominated education in marginalised communities, as children and teachers were unprepared for online learning. Digital access and UDL didactics and imperatives for pandemic preparedness and achieving Sustainable Development Goal 4 on quality childhood learning outcomes in developing countries

Methods

Research Design

A mixed methods design involving participatory and co-approaches was used to generate both qualitative and quantitative data for evidence generation. According to Campbell (2002), participatory methods generate qualitative and quantitative data using interviews, visuals, ranking or scoring instruments. Popular approach among development researchers, such as social justice tackling barriers (Ilboudo Nebie et al., 2024). Participatory case studies encourage dialogue between the researcher and the researched and are considered appropriate for exploring emergent themes in marginalised communities (Evans et al., 2010). However, generating data involving children and teachers in live class sessions requires trade-offs and balancing acts not to disrupt learning activities. While reliability issues remain challenging for ethnographic-based studies, we used digital voice recorders, checklists, and questionnaires to minimise instructional distruptions to adhere to subject matter experts' judgments for constructs and interview items. Yin's (2016) interview format suggests the graduated stage for gathering narrative information, with the first of the three interviews establishing the context of a participant's experience, covering the personal background; participants reconstruct experiences relating to the topic of study; and a third interview may ask the participants to reflect on the meaning of the experiences. Hence, participant-observation techniques for this study enabled enumerators to act as co-facilitators in classrooms at different stages. School entry initiation with head of schools and class teachers, explained classroom data generation from teaching plans, resources, didactics, children's interactions, assessment, and reflexivity. The quantitative data were followed by teacher surveys for validation and triangulation of edtech tools utilisation in post-COVID classrooms.

Administration

Eight enumerators with learning sciences backgrounds observed facilitators and children in 102 rural, peri-urban and urban schools in coastal, forest and savannah zones, focusing on STEM-based subjects – numeracy, literacy, science, and information and communication technology (ICT). The observations were followed by debriefing sessions and brief interviews to document children's and teachers' experiences with digital devices, core competencies, inquiry-based learning, access, neurodiversity, universal design for learning, and standards-based learning during and after COVID-19. Despite its elaborate and expensive process, we chose codesign, which departed from the survey evidence generation for edtech studies associated with edtech research in developing (e.g., Anapey & Aheto, 2022). Using a Likert-type scale to record instructional practices in context, teachers shared their experiences guiding evidence translation for instructional strategies.

Instrumentation

The multiple research instruments (interviews, action research, desk reviews) deployed triangulated the main research questions for the study. Our field experiences confirmed construct validity based on National Educational Technology Standards for teachers (NETS.t), digital resources availability, adequacy, utilisation, teacher TPACK, and children's learning environments across the study areas.

Pre-Testing and Validation

Inter-tater reliability outcomes involving three enumerators observed children learning environments, edtech ecosystem, accessible education, equity-based learning, and core competencies outlined in the observation protocol. Overall, 304 girls and 134 boys were documented during 12 instructional sessions from three private and nine public schools involving Basic 2, Basic 4, and Basic 6 classrooms in the Central Region of Ghana. Six male and female teachers participated in the pretesting.

One-way ANOVA was used to validate the internal consistency for the items with results confirming three field rater's agreement on the eight main latent variables, including Core Competency ($F(2) = 0.61$, $p = .57$), Differential Learning ($F(2) = 1.29$, $p = .32$), Problem Solving ($F(2) = 0.50$, $p = .62$), Critical Thinking ($F(2) = 0.41$, $p = .68$), Creative Thinking ($F(2) = 0.32$, $p = .74$), Conceptual Thinking ($F(2) = 0.17$, $p = .85$), Inclusive Education ($F(2) = 0.13$, $p = .88$), and Creative Pedagogical Approaches ($F(2) = 0.40$, $p = .68$). The observed non-significant values compared with the decision rule of $p < = .05$, Raters (1-3) were unanimous with their observations during the pre-test.

Classroom Observation Checklist

On a Likert-type scale, children's edtech ecosystems were rated as 1 (Not Observed), 2 (Ineffective), 3 (Somewhat Effective), and 4 (Effective). The children's classroom observation protocol covered new and widening digital divides, access to foundational learning needs, computer-supported collaborative, and inquiry-based learning targets in post-pandemic classrooms.. While checking children's digital learning resource utilisation and conducive learning environments, gender equity, inclusion, and cooperative skills from Ghana's standards-based education system, physical space for safety for special needs children was also documented using Google Forms categorised into five sections. (see Appendix A). Sections 1 and 2 provided ethical consent, while background information such as geographical location, class size, school category, teacher characteristics, and strands were documented in Section 3. Computer resources, school setting for inclusion and instructional resources occupied Section 4, Section 5 itemised inquiry-based pedagogy, global skills with 38 items, competency-based assessment (8 items), classroom arrangements, children's questioning skills, and reflective questions for facilitator after the lesson. STEM-based lessons were observed for an average of 40 minutes, and a 10-minute interview protocol of teachers about their technology pedagogical content knowledge (TPACK), instructional reflection, and suggestions for effective inquiry-based learning.

Reliability Outcomes for the Main Protocols

Table 1 documents teachers' technology pedagogical content knowledge (TPACK) with 32 items categorised and coded under seven sub-scales - i) Differential Teaching Practices (DTP) (IBL1, IBL2, IBL3), ii), Problem-Solving (PS) (IBL4, IBL5, IBL6), iii) Critical Thinking (CriT) (IBL7, IBL8, IBL9, IBL10), iv) Creativity (CreaT) (IBL11, IBL12, IBL13, IBL14), v) Conceptual Thinking (ConT) (IBL15, IBL16, IBL17, IBL18), vi) Inclusive Education (InEd) (IBL19, IBL20, IBL21, IBL22, IBL23), vii) Developmental Psychology Knowledge (DPK) (IBL25, IBL28, IBL29, IBL30, IBL33, IBL34), and vii) Creative Pedagogical Content (CPK) (IBL24, IBL26, IBL27, IBL28, IBL32, IBL36, IBL38).

Retaining latent variables with weak coefficients has implication for relationship testing in the behavioural sciences. However, Field (2018) recommends values of .4 and above for exploring new concepts. Inspection of the Cronbach's score of .43 for Problem Solving (PS) skills met Field's proposition as the remaining seven constructs ranged between strong (DTP = .93) and moderate (PS = .56) for the final 102 classroom observations in this study (Table 1). Meanwhile, our pre-test items from 12 schools also yielded strong (CPK = .97) and weak (PS = .43), with items ranging between 3 (DPT) and 7 (CPK); providing assurances for hypothesis testing.

Table 1. Pre-test and Endling Reliability Statistics for Observed Constructs

Children's Core Competencies	No. of Items	Cronbach's Alpha Based on Standardised Items	
		Pre-test	Endline
Differential Teaching Practices (DTA)	3	.858	.932
Problem Solving (PS)	3	.434	.556
Critical Thinking (CriT)	4	.836	.816
Creativity (CreaT)	4	.621	.688
Conceptual Thinking (ConT)	4	.844	.799
Inclusive Education (InEd)	5	.876	.690
Developmental Psychology Knowledge (DPK)	5	.812	.850
Creative Pedagogical Content (CPK)	7	.966	.871

Sampling and Sample Characteristics

Sampling Approaches: Nested sampling involving simple random sampling techniques with Excel Rand(...) function was used to generate random numbers for four education regions (25%) from 16. Secondly, five districts per region were sampled using a randomised Excel spreadsheet. Five schools from each district were also picked from clusters based on Ghana Education Service school mapping.

Samples depended on each activity from the above participatory research design.

Children's edtech ecosystems were observed in classrooms receiving national standard-based assessments under the Ministry of Education at the time of the study. Four of Ghana's administrative regions were randomly selected using inclusive criteria of geographical and standards-based curriculum implementation, gender equity, digital access, and core competencies for private and public schools. From Ghana's standards-based classrooms,102 teachers, 46% (n = 47) private and 54% (n = 55) in public school environments. On average, 17 (SD = 7.7) girls and 16 (SD = 7.2) boys: and 33.07 (SD = 13.68) class sizes in private and public basic schools. Indeed, 66% (n = 67) of participating schools were in Ghana's rural community, while 34% (n = 35) were in cosmopolitan cities. Also, Figure 3 shows 58% (n = 59) females and 42% (n = 43) male teachers taught children in Basic 2, 4, and 6 classrooms in Volta (41%, n = 42), Ashanti (24%, 24), Upper West (24%, n = 24), and Greater Accra (12%, n = 12) regions. More girls were sampled 17 (SD = 7.73) girls and 16 (SD = 7.21) boys per class. A minimum of 3 girls and four boys, and a maximum of 40 girls, 39 boys per class also participated in this study (see Figure 3).

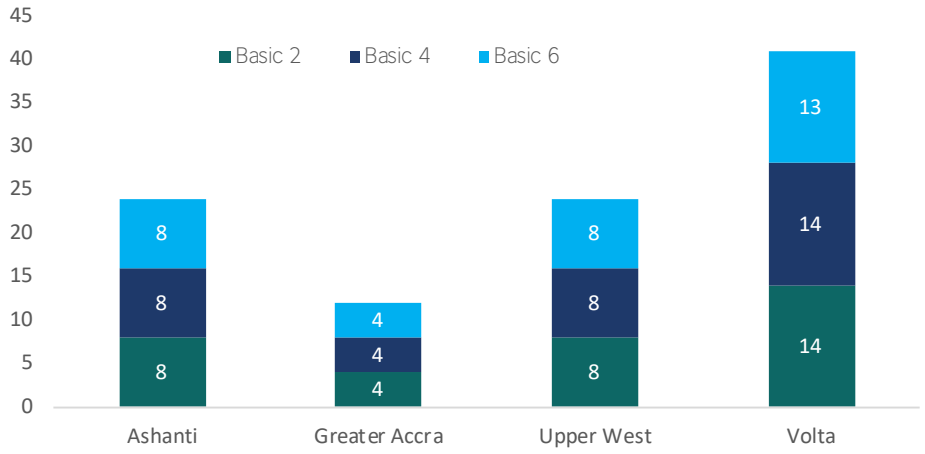


Figure 3. Regional distribution of classrooms observed

Similarly, 65% (n = 66) of rural and 35% (n = 35) urban classrooms, 46% (n = 46) private and 33% (n = 55) public schools were explored in this study (Figure 4).

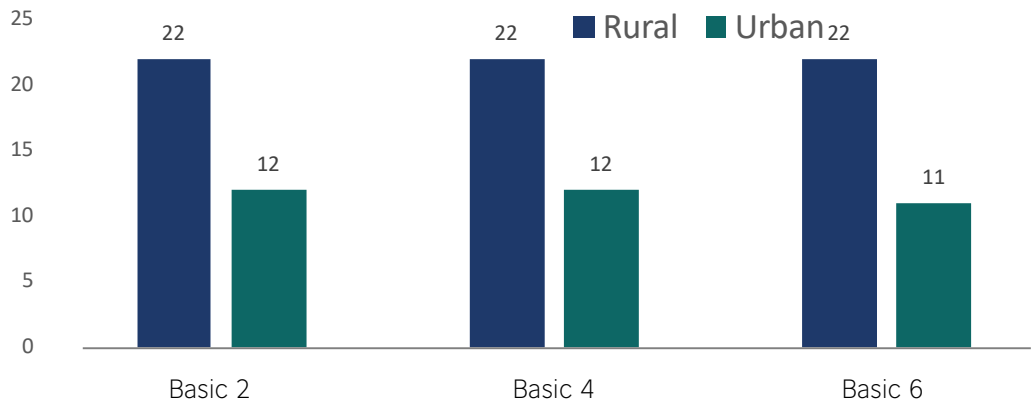


Figure 4. Rural and urban classes observed

Figure 5 shows the years of teaching by private and public school teachers from the four regions. Peak service years showed 1-5 years for private school teachers compared with 6-10 years for public schools in this study. Also, the declining years was drastic in private schools with a high attrition rate. As years increase, the number of private school teachers decreases, with more public school teachers having prolonged years in classrooms. Figure 5 is imperative for teacher professional development and guiding children through quality learning. While extended years on the job can be necessary for acquiring ethical and practical knowledge, losing teachers to other lucrative sectors appears to be the trend in education at the pre-tertiary level in developing countries.

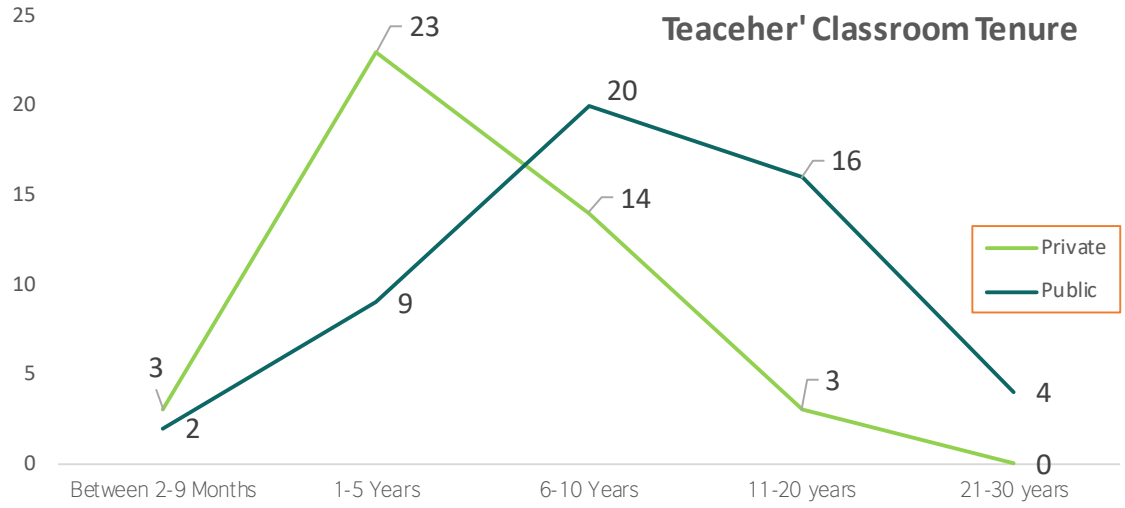


Figure 5. Years of teaching experience in private and public schools

Figure 6 reports teacher licensure status and academic qualifications, with more first-degree holders licensed in public schools than private schools. While public schools recorded more post-graduate facilitators, private schools were engaging the services of secondary school holders.

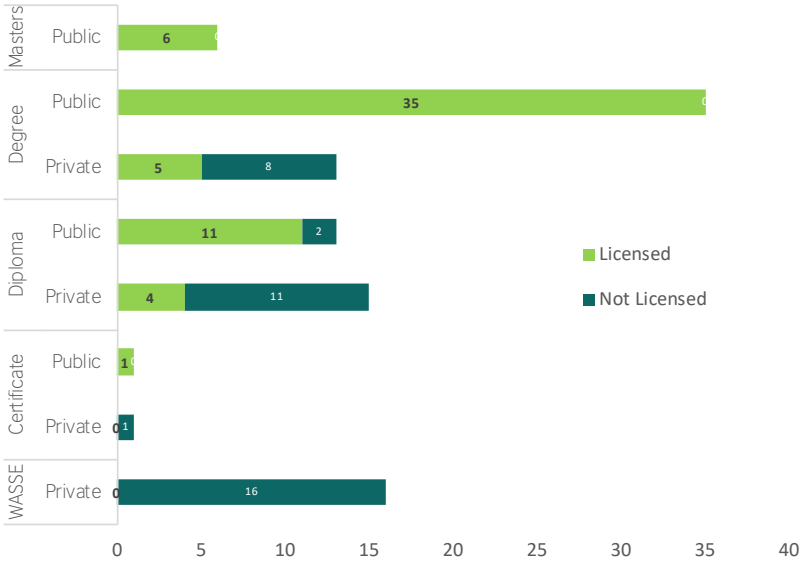


Figure 6. Teacher licensure and academic qualifications

Teachers' academic qualifications and professional licensure status were explored in Figure 6, with 85% n = 53) of public and 14% (n = 9) private school teachers licensed. While 95% (n = 36) private school teachers were unlicensed to teach, 71% (n = 31) held between senior high secondary school and diploma qualifications, with 29% (n = 13) as first degree holders. Government school teachers licensed a minimum diploma certificate; with, 75% (n = 41) first and second degree holders and 25% (n = 14) post-secondary and diploma holders reported in this study. With a mean tenure of 8.13 (SD = 6.01), teachers' tenure ranged between 2.12 years and 14.14 years, with 33% (n = 255) holding degrees between senior high school and diploma. First degree qualifications were 61% (n = 458), and 5% (n = 30) post-graduates participated in the study.

Teacher survey

Teacher technology pedagogical content knowledge (TPACK) is required for evidence-based decision making by education stakeholders while supporting children's learning experiences in the digital age. Hence, using a survey approach, teachers' edtech experiences were measured to triangulate our classroom observation data. Primarily, the survey assessed school resilience against future pandemics and disruption to children's education in the post-COVID era. Early grade teachers' readiness to instruct online was evaluated with a learning management system, summative and formative assessment, feedback, multimedia creation, online support, and foundational ICT skills.

From Appendix B, web-based instruction was measured with a 6-point Likert-type scale items with exploratory factor analysis (EFA) values between .49 (I can adhere to the institutional policies online) to .99 (I can securely report grades to students and input final grades into the institutional grading system as required). Also, the 23 online learning constructs yielded a TVE (total variance explained) of 66.92%. At the same time, the Kaiser-Meyer-Olkin (KMO) Test for the suitability of our observation data showed a highly significant value. 96 online readiness ($\chi^2(253) = 10897.19$, $p = .001$) in the study.

While 775 samples were drawn from three zones, with 53% (n = 412) females and 47% (n = 363) males, 52% (n = 406) of the public and 48% (n = 369) private schools participated in the study. Regional distribution showed 32% (n = 246) in Greater Accra, 35% (n = 264) in Central, and 33% (n = 254) in the Upper West region, with 74% (n = 558) B1-B6 and 26% (n = 194) Junior High School (JSS) class teachers participating in the survey.

Data Analysis Approaches

Generating predictive models for knowledge translation guided the CERES research project. Minimising a Type-1 error of rejecting the effect based on false positives when statistical tests reject a true null hypothesis about children's edtech ecosystem parameters due to a lack of diligence during data management was important for this study. While Field (2018) guides researchers to navigate false predictions by adopting Fisher's criterion of $\alpha = .05$, Tabachnick and Fidell's (2013) framework of matrix data was explored for critical assumptions, including normality, linearity, equal variances, and independence of scores, which were observed for the analysis. We also employed visualisation techniques

including minimum, maximum, mean, median, modes, standard deviation, and outlier checks to avoid inflated means likely to bias significance testing. Research questions were analysed using descriptive statistics, chi-square, t-tests, ANOVA, and binary logistic regression.

Ethical Considerations

Multiple ethical approaches were used, including institutional, school, and sample levels, and institutional review board clearance guided the study. Ethical Committee for the Humanities under the University of Ghana, with approval number # ECH/184/22-23, was secured in addition to an authorisation letter to the Regional Directors of Education under the Ghana Education Service, which was secured for the observation and survey data. At the school level, headteachers acted as gatekeepers who granted consent to enumerators to observe children's edtech ecosystems. opt-in and opt-out consent was employed for children based on anonymisation considerations, including confidentiality, voluntary participation and data encryption. Final participants' data were reported with group summaries and identities coded to ensure individual information was not traceable to any school, child, or teacher. Field data were stored in a secure repository.

Results

The results section outlines statistical results from the children's edtech ecosystem as a reflection of digital learning experiences, new and widening digital divides, accessible education, and computer-supported collaborative learning using observational and survey data from a standards-based education system. Evidence generation impacting knowledge translation in children's post-COVID classrooms, how digital access impacts children's collaborative learning, and assistive technology for inclusive education dominated our evidence generation. Also, teacher readiness to adopt online instruction in pandemics provided a framework for testing resilience in education systems supporting children's learning during school closures from a Global South country's perspective.

Research Question 1: Children's Digital Access and Pandemic Readiness

Overcoming digital disparities in children's learning environments is essential for SDG 4 on quality education in developing countries. While several reports highlighted the impact of computer technology on 21st-century skills, scientific interventions are needed to reduce growing inequalities and children's learning loss during pandemics, wars, and poor instructional strategies. Today, global learning outcomes are being influenced by digital personalisation studies in childhood learning environments (Kucirkova, Campbell, & Cermakova, 2023). Hence, global learning outcomes are based on the availability of digital resources in schools. Two main findings emerged under Research Question 1 to inform policy initiatives about digital access and ecosystems for pandemic readiness, and inquiry-based pedagogy and brain science-inspired learning in Ghana's standardised-based classrooms after the 2019 pandemic.

Children's Digital Ecosystem Assessment

While computer access is imperative for advancing children's 21st-century skills, education financing gaps are equally impacting deployment to marginalised schools in Sub-Saharan Africa. Hence, Figure 7 depicts digital access with private schools investing more in computer laboratories than government-funded schools by 32% (n = 15). In comparison, 69% (n = 9) of schools without (none) teacher digital device ownership were in favour of public school teachers with 6% (n = 8) smartphone and 21% (n = 7) laptop ownerships; partly due to the Ministry of Education's joint financing scheme for public school teachers to own laptops.

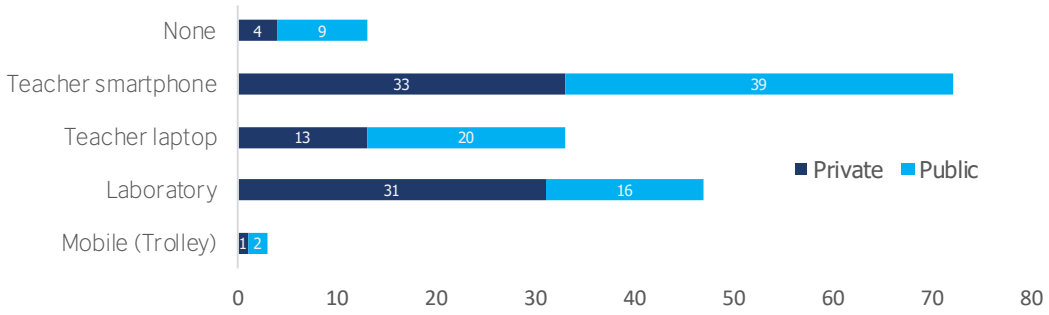


Figure 7. Digital device ownership in public and private schools

Using multiple response items, Figure 8 illustrates the type of digital device ownership among male and female teachers in Ghana's Basic 2, 4, and 6 classrooms. Three schools operated a mobile plan among different ownership plans, while 27 male and 20 female teachers reported access to digital laboratories. On individual laptop ownership (n = 33) and lack of access to digital tools (n = 13) in schools, an almost equal number of male and female teachers fell in the two categories. However, 11% (n = 8) of male teachers recorded smartphone ownership more than females in this study.

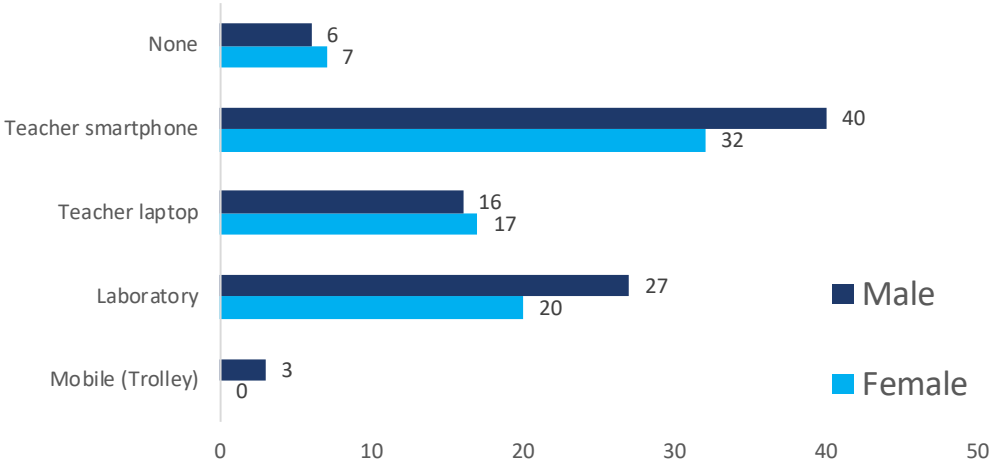


Figure 8. Teachers' gender and digital device ownership

Widening Digital Divide from School Infrastructure Provision

We observed a 2:1 computer ratio favouring children in Ghana's private schools. Indeed, 66% (n = 31) of available edtech tools in the classroom were recorded in private schools compared with 22% (n = 12) in public schools (Table 2). 58% of schools had no digital access, compared to 42%.

Table 2. Availability of Computers in Private and Public Schools

Computer Availability	School				Total	Total %
	Private	Private %	Public	Public %		
Unavailable	16	34.04	43	78.18	59	57.84
Available	31	65.96	12	21.82	43	42.16
Total	47	100	55	100	102	100
Total %	46.08		53.92		100	

Research Question 2: Quality Accessible Education for Neurodiverse Children in Foundational Classrooms

We explored categories of neurodiverse learners and accessible environments supporting the use of assistive tools to meet children's global learning outcomes during pandemics. Emerging debates about vestiges of COVID-19 require stakeholder interventions on managing children's learning loss and quality education outcomes mandated in Sustainable Development Goal 4, while advancing digital access and inclusion for all in marginalised communities. With support from social justice voices following the 1948 UN Declaration of Human Rights, organisations are committing resources to support learner variability and differential abilities in marginalised communities globally. Curriculum reforms in West Africa also recognise inclusive education for children within standards-based didactics (MBSSE, 2020; NaCCA, 2018). Therefore, we examined the state of education for special needs children during and after the pandemic from a Global South nation's perspective to answer the question of the preparedness of mainstream school systems for neurodiverse children in times of endemic or pandemic.

Neurodiversity in Foundational Classrooms

Figure 9 depicts 11 learning problems observed by classroom teachers with 36% (n = 60) literacy, 17% (n = 28) numeracy, and 11% (n = 18) ADHD conditions dominating the observation. Neurodevelopmental conditions, including autism, physical disability, dysgraphia, and Down syndrome, were also noticed in Ghana's mainstream classrooms, Public schools reported more disability challenges than private schools. Specifically, 52% of children with literacy difficulties were in mainstream classrooms and 48% in private schools. Differentiated instruction using assistive devices to address children's needs is essential for advancing accessible education targets for marginalised schools.

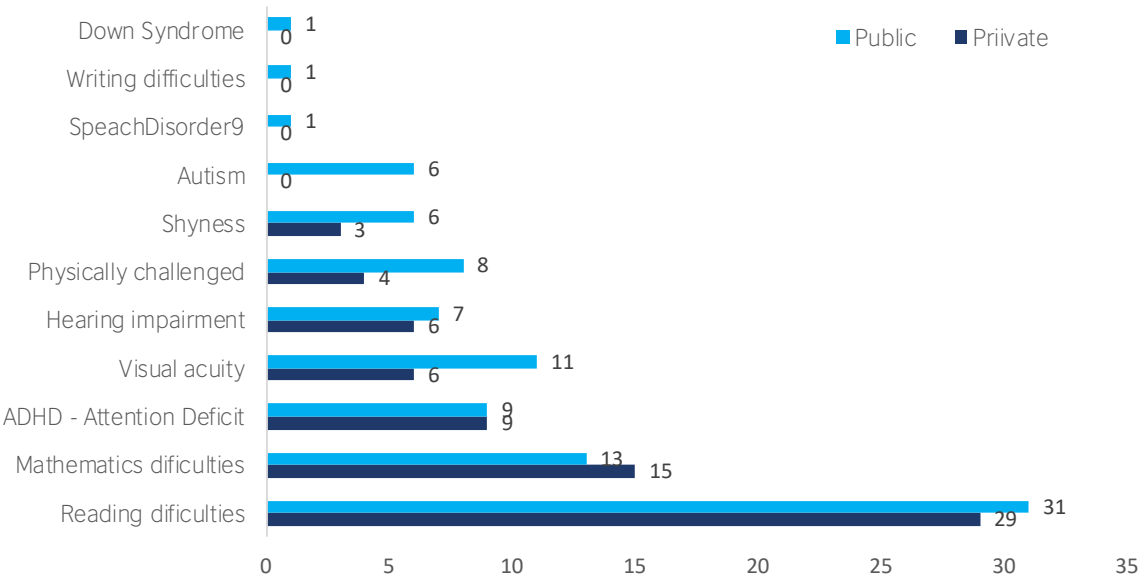
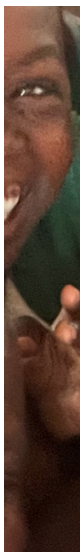


Figure 9. Special learning needs in early-grade classrooms



The mean scores for conditions Not Observed (M = 1.41, SD = 1.31) for 102 early-grade teachers were explored with tenure groups between 2 months and 5 years (M = 1.72, SD = 0.42; n = 37), 6 to 10 years (M = 1.92, SD = 0.54; n = 34) (Appendix F). We confirmed the descriptors with tenure as a likely predictor of differentiated instruction in post-pandemic classrooms using a Monte Carlo Simulation in Hypothesis 4:

Disability Friendly Learning Environments Assessment

In Figure 10, 17% (n = 17) of the schools were well structured to aid accessibility with 83% (n = 85) of the school environments had accessibility challenges for children with physical disabilities. Hypothesis 6:

H_A1: Accessible environments will not differ for children in private and public schools.

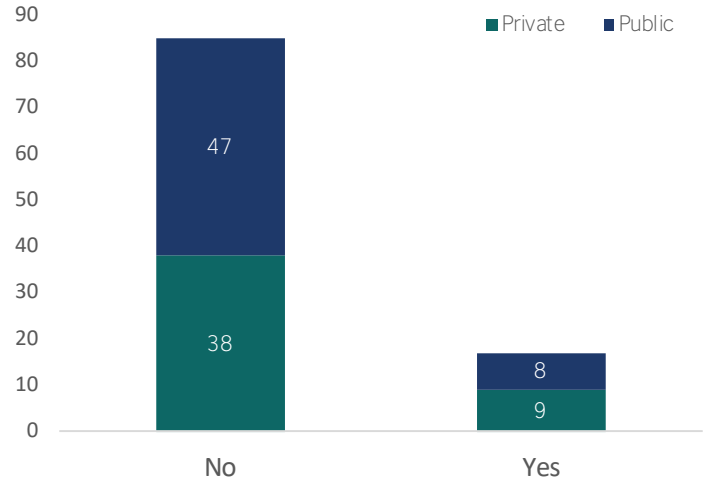


Figure 10. Physical accessibility for children with disabilities

Despite the existence of the Inclusive Education Policy Ghana Education Service, Ministry of Education, 2013). disability facilities did not significantly differ ($\chi^2(1) = 0.39$, p = .53) in private or government-assisted basic schools.

Research Question 3: Digital Adoptions for Children's Inquiry-Based Learning and Global Competencies

The study examined the translative impact of digital access on children's inquiry-based and global skills acquisitions in foundational classrooms. Considering the effects of convergence media on quality learning outcomes, including critical thinking and problem solving, collaboration and communication skills, Research Question 3 gauged teachers' creative didactics for foundational learning and technology pedagogical content knowledge interventions in Global South schools.

Instructional Media for Post-Pandemic Children's Education

Based on multiple classroom visits, the study examined instructional media used in foundational classrooms. Figure 11 illustrates that 82% of the media used in the school were textbook-based, with 10% used in multimedia clips such as videos during teaching. Play-based pedagogy constituted 8% of children's learning approaches in early-grade classrooms.

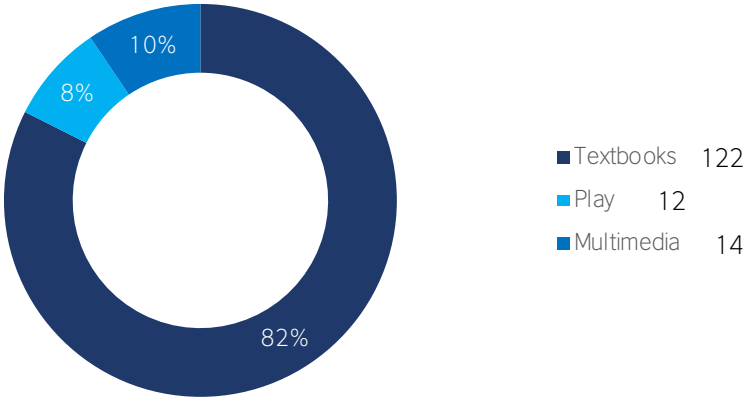


Figure 11. Instructional media used in children's classrooms

Figure 12 also illustrates the distribution of seven subjects observed in private and public schools in the study areas. English Language constituted 26% (n = 25), 24% (n = 23) mathematics, 23% (n = 22) science, and 16% (n = 16) Our World Our People (OWOP).

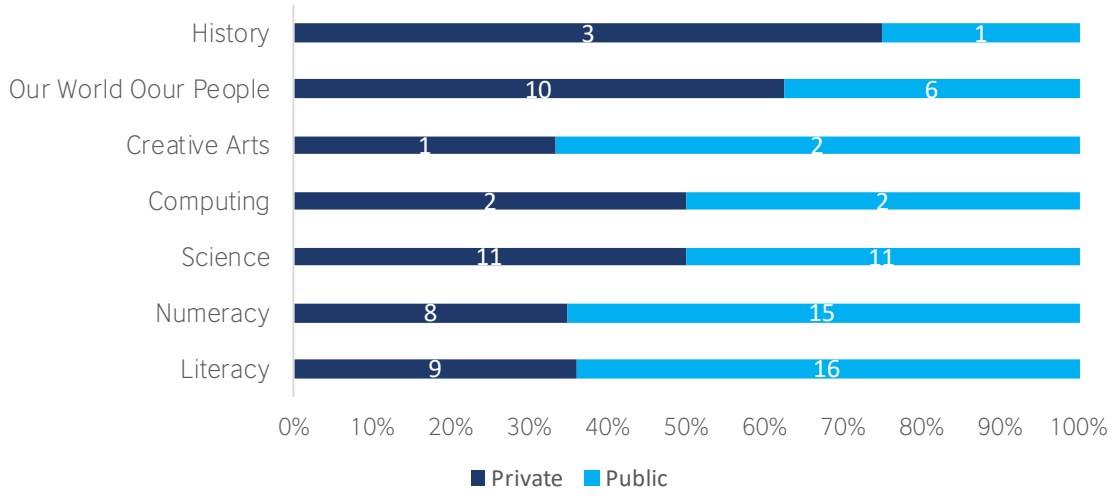


Figure 12. Strands observed in the study

Collaborative Learning for Children in Public and Private Schools

Figure 13 supported the finding that collaborative learning tasks remained low in Ghana's early-grade classrooms, with only 2% of children's observed in groups in this study. Overwhelmingly, classwork and verbal assessment approaches dominated children's learning.

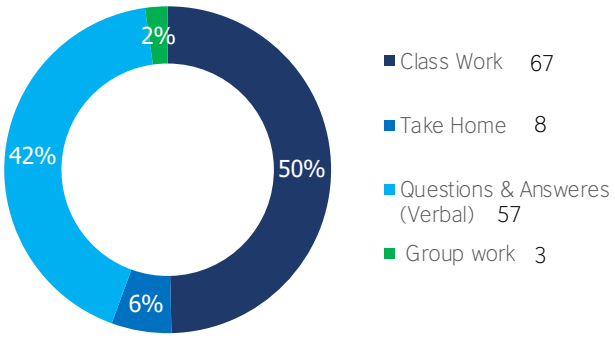


Figure 13. Early-grade assessment approaches

Inquiry-Based Learning Practices

The global partners in education (GPEs) are empowering citizens to adopt emerging technologies to mitigate unintended consequences of global health and develop global skills through the practical application of ICT tools. In tandem with Ghana's standards-based curriculum, children's learning environment transformation, creative instructional strategies, and availability of digital tools are imperative for translating creative pedagogies into children's core competencies. Hence, the study examined children's digital access and core competencies. Figure 14 shows classroom arrangements supporting collaborative learning pedagogy, with 87% traditional classroom sitting arrangements, while 15% lessons had horseshoe or circular sittings suggestive of inquiry-based activities. However, we observed that children were sitting in groups with no collaborative activities to solve learning problems, as instructions were delivered with their backs to the writing boards while answering questions independently.

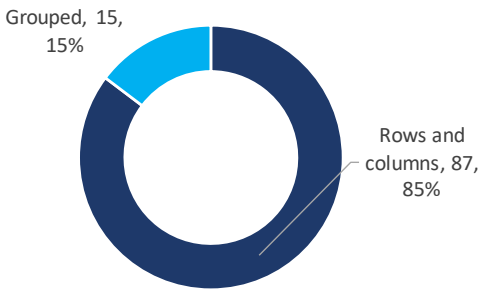


Figure 14. Classroom arrangement for collaborative tasks classroom

Table 3 presents the disaggregated findings on global skills informing pedagogical interventions on a scale of 1 (Not Observed) and 4 (Central to Lesson Delivery). The average score of 2 (Introduced but not Assessed) and SD above 1 illustrated a heterogeneity score on global skills from Ghana's standards-based classrooms. We observed that teaching in Basic 2, 4, and 6 classrooms was dominant in the knowledge domain, with facilitators presenting sub-strands detailed in the standards-based syllabus through question-and-answer sessions. Hence, critical thinking emerged as the dominant trait observed while problem solving, innovative approaches, cultural identity, global citizenship, leadership and digital skills were not observed in this study. Primarily, children were supposed to solve real-world problems to complement individual learning, such as answering questions in workbooks, but teachers are yet to incorprate competency-based bubrics development for competencies. Also, the dominant row and column classroom arrangements (see Figure 9) confirmed teachers' inability to evaluate children's 21st-century skills in this study.

Table 3. Mean Scores of Children's Global Competencies

Core Competencies	Mean	SD	Variance
Critical Thinking	2.55	1.347	1.814
Problem Solving	1.47	.855	.731
Innovation	1.19	.578	.334
Cultural Identity	1.31	.526	.277
Global Citizenship	1.23	.421	.178
Leadership	1.25	.438	.192
Digital Literacy	1.09	.449	.202

For the global partners in education, new and widening digital divides have broader implications for learners in Sub-Saharan Africa. Schools are slow to adopt digital tools to support the personalised learning needs of children. At the same time, access issues remain challenging for government schools, gender disparities, geographically marginalised regions, cost, and teacher TPACK capacity continue to blur the global vision of quality learning. Children's core competency depends on practical lessons. While learners solve problems using content knowledge, little is known about assessment techniques that support collaborative skills for children.

As a post-hoc analysis, the study explored the mean values in Table 3 for confirmatory statistical decision-making in Hypothesis 1:

HA2: Digital access would translate into children's global skill scores in the classrooms.

Using binary logistic regression, 62.7% of % Availability and Unavailability of computers in schools were predicted when the predictors were entered into the model (Appendix C). Overall statistics also showed a non-significant association between children's digital availability and global skills ($\chi^2(1) = 0.85$, $p = .36$) (see Appendix D). The non-significance of the constant in the model denotes that supplying computers to schools did not

impact core competencies in this study. This confirms Ames's (2019) findings in Latin America's OLPC project, where teachers could not translate the Lego laptops into meaningful learning for pupils.

For effect size determination, Table 4 shows Negelkerke's R2 of 10.3% as the variance explained in the model from the seven predictors. Hence, the study rejected HA2 and concluded that digital provision in early grade classrooms was not a panacea for supporting children's global skills in post-pandemic classrooms. This finding has implications for teacher professional development and curriculum training for standards-based education systems in Sub-Saharan African nations.

Table 4. Binary Logistics Regression Model Summary

Step	-2 Log likelihood	Cox & Snell R^2	Nagelkerke R^2
1	130.773[a]	.076	.103

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

While teacher creative pedagogical content knowledge was statistically significant ($\chi^2(1) = 4.09$, $p = .04$), the probability of digital tools impacting problem solving ($\chi^2(1) = 0.64$, $p = .42$), critical thinking ($\chi^2(1) = 0.58$, $p = .45$), creative thinking ($\chi^2(1) = 0.05$, $p = .83$), conceptual thinking ($\chi^2(1) = 2.27$, $p = .13$), inclusive practices ($\chi^2(1) = 0.56$, $p = .46$), and differential learning ($\chi^2(1) = 0.61$, $p = .44$) non-significant in the study. According to the beta scores, teacher creative pedagogy ($\beta = 3.59$) was three times more likely to occur in schools without digital tools (81%) than in schools with computer laboratories (37%) and for children's conceptual thinking ($\beta = 3.28$). However, problem solving ($\beta = 0.74$), critical thinking ($\beta = 0.64$), creativity ($\beta = 0.89$), inclusive didactics ($\beta = 0.54$), and differentiation ($\beta = 0.51$) were not likely to occur in the current standards-based instructional environment in Ghana's schools (Appendix D).

Global Skills and Creative Learning in Children's Post-Pandemic Classrooms

The research observes 16 learning activities as indicators of children's inquiry-based learning in Ghana's classrooms. Appendix H shows children's engagement with content standards based on five activities, including strand definitions (M = 2.54, SD = 1.05), workbook-based assessment of strands (M = 2.52, SD = 1.002), solution generation in form of verbal questions and answers (M = 2.48, SD = 1.03), revisiting relevant previous lessons (M = 2.47, SD = 1.11), and engaging children to reframe ideas (M = 2.44, SD = 1.001). Based on the scale of 1 (Not Observed) to 4 (Effective), the study concluded that though teachers were observed employing the five learning strategies, they were Ineffective in supporting children's core competencies, including critical thinking and problem-solving, innovation and initiative, collaboration and communication,

personal development and global citizenship skills in this study.

The eleven approaches including using imagination (M = 1.96, SD = 0.96), ideas development and elaboration (M = 1.95, SD = 0.96), brainstorming (M = 1.92, SD = 1.06), group learning (M = 1.78, SD = 1.03), real-world problem-solving (M = 1.62, SD = 0.76), differential instruction (M = 1.58, SD = 1.01), standard-based learning outcomes sharing (M = 1.58, SD = 0.81), cross-cutting themes from Sustainable Development Goals (M = 1.55, SD = 0.78), linking strands to children's career interests (M = 1.77, SD = 0.53), and developing conceptual thinking skills (M = 1.11, SD = 0.46) were not missed in 102 post-COVID classrooms in this study.

The study explored teachers' rubrics usage to assess children's creative learning outcomes such as critical thinking, problem-solving, communication, personal development, teamwork and personal development.

HA3: Licensure status will impact the usage of the children's core competencies assessment.

The result showed no statistical association ($\chi 2(3) = 1.31, p = .73$) between rubric use to assess global skills in private and public schools by licensed, yet-to-be licenced and unqualified teachers. Our findings showed that core competency assessment was not observed in this study.

The impact of educational technologies on children's inquiry-based learning outcomes was also explored as part of a larger context for support systems in denudational classrooms in Hypothesis 3:

HA4: In the post-pandemic era, inquiry-based learning will not differ for children in private and public schools.

Collaborative learning was observed in private (M = 1.40, SD = 0.32, SE = 0.05; n = 47) and public (M = 1.58, SD = 0.60, SE = 0.08; n = 55) post-COVID classrooms using independent samples t-test. The Levene's test for equality of variances was large (F = 6.33, p = .013), violating the assumption of equal variances. Therefore, equal variance unassumed was opted, and the result showed a non-significant difference (t(85) = 1.92, p = .06; CI [0.36: 0.01]) between private and public schools on collaborative learning pedagogy (Appendix G). Given that more public school teachers obtained licensure certifications than private school teachers, this finding is imperative for inquiry-based instruction and reforming pedagogical institutions in Ghana.

Research Question 4: Pandemic resilience and online instruction in marginalised schools

Research Question 4 explored school indicators and pandemic readiness in Global South schools. While access to digital tools and learner characteristics are imperatives for quality learning within the SDG4, teacher pedagogical approaches, professionalism, multimedia, and online instruction skills are significant variables for pandemic resilience.

Teacher Licensure Impact on Creative Pedagogical Practices

The study examined teachers' pedagogical knowledge and licensure status in Ghana's basic schools. Figure 15 illustrates teachers' licensure by the National Teaching Council (NTC), with 17% unqualified to attempt the examination from private schools. These are holders of non-education-related qualifications, including senior high school certification. Also, 61% of teachers were recorded as passing the examination, either exempted or having written the NTC prescribed papers. Finally, 22% of facilitators did not pass the national examinations in this study.

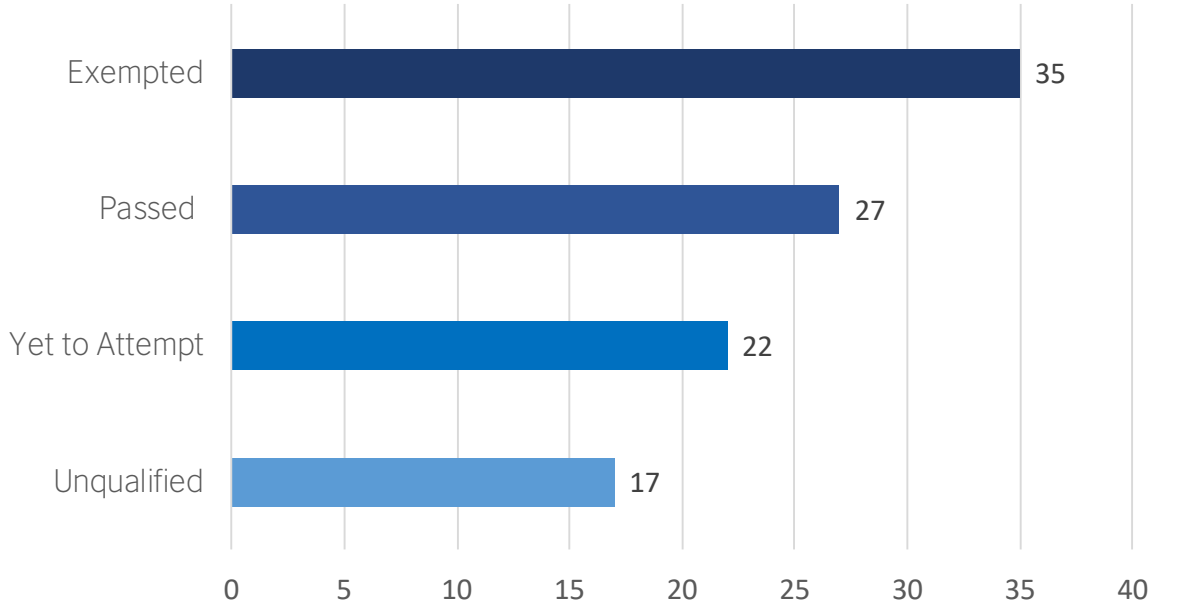


Figure 15. National Teaching Council licensure status

Table 5 shows Basic 2, 4, and 6 teachers' average scores on creative teaching practices categorised into three: exempted, written, and Qualified. Yet, no attempt has been observed using creative pedagogies. Though teacher pedagogical knowledge was significant in the logistic mode[1] for HA2, it did not translate into classroom practical learning activities in this study. Factors such as examination-focused teaching, learning environment, and lack of play-based materials to support children's inquiry-based didactics could explain the observed mean differences in Table 5

Table 5. Licensure Teachers' Mean Scores on Creative Pedagogy

	N	Mean	SD	SE	95% CI for Mean	
					Lower Bound	Upper Bound
Exempted	35	1.44	0.48	0.08	1.28	1.61
Written	27	1.73	0.62	0.12	1.48	1.98
Yet to Attempt	22	1.42	0.43	0.09	1.23	1.61
Unqualified	17	1.39	0.24	0.06	1.27	1.51
Total	101	1.50	0.50	0.05	1.41	1.60

Based on the results from Research Question 3, illustrating gaps in children's core skills, we explored the predictive impact of teacher professionalism on creative pedagogies supporting children's 21st-century skills. In Hypothesis 4:

HA5: *Creative instructions will be impacted by teachers' licensure status in Ghana's standards-based learning environment.*

With homogeneity of variance scores tenable (Levene's (3,97) = 2.56, p = .06), we explored the statistically significant differences between the groups using a one-way ANOVA. Table 6 shows a considerable difference (F(3) = 2,67, p <= .05) between teachers who were exempted, wrote the exam, and had yet to attempt creative instructional strategies in this study.

Table 6. ANOVA Pedagogical Approaches

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.88	3	.63	2.67	.05
Within Groups	22.68	97	.234		
Total	24.55	100			

Using a multiple comparisons approach (LSD), there was a statistical difference between teachers who wrote NTC exams and those exempted (p = .02), yet to attempt and written (p = .03), written and unqualified (p = .03) (see Appendix E). Contrarily, statistical differences were not observed between groups, yet to attempt and exempted (p =.87), exempted and unqualified (p = .83), and unqualified and exempted (p = 71).

Hence, we retained HA5 and concluded that licensing of teachers appeared to influence their innovative classroom teaching that focuses on inquiry-based learning required for children's 21st-century skills in the post-COVID period.

Teachers' Digital Skills for Educational Sustainability

As new forms of digital divides, low teacher capacity, and unavailability of digital resources impact children's quality of learning and collaborative skills in Ghana's classrooms, teachers' online facilitation skills would be essential for building resilient schools in pandemic reemergence. Therefore, the research examined teacher web-based instruction readiness in Ghana's basic schools using an online survey of 802 teachers. Using multiple response items, early-grade teachers were asked to identify which skills they would require to teach online should there be a closure of schools due to health restrictions. We successfully coded 274 independent views for significant testing (Table 7)

Results highlight generic digital skills of operating the computer (58%), social media (24%), and internet surfing for research and teaching (13%). However, critical skills required for effective online teaching and integration, such as multimedia (1%) skills, data analytics (1.7%), programming (1.9%), netiquette (2.4%) skills, followed by keyboarding (4.1%) and online assessment (4.5%), received the lowest rating amongst teachers in this study. Hypotheses explored gender differences in teachers' digital skills in readiness for online pedagogy to observe social distancing protocols.

H_A6: *Male and female teachers will not differ in online instructional skills.*

The second half of Table 7 demonstrates a chi-squared distribution as teachers spent more time on social media than females ($p < 05$), as the only significant digital skill observed in the study. On the other hand, gender was a non-significant predictor of teachers' basic computer knowledge ($p > .05$), browsing ($p > .05$), multimedia ($p > .05$), online learning assessment ($p > .05$), typing skills ($p > .05$), online etiquette ($p > .05$), machine learning and coding for instruction ($p > .05$), and data analytics skills ($p > .05$).

Table 7. Teacher Digital Skills Gaps for Online Teaching

Digital Skills	Gender				Total		χ^2 (1-tailed)
	Male		Female				
	n	%	n	%	(n)	%	
Generic ICT skills	156	47.1	175	52.9	331	57.1	$\chi^2(1) = 1.12, p = .47)$
Social media skills	75	53.6	65	46.4	140	24.1	$\chi^2(1) = 3.34, p = .04)$*
Internet & skills	29	37.2	49	62.8	78	13.5	$\chi^2(1) = 2.02, p = .10)$
Multimedia	27	39.1	42	60.9	69	11.9	$\chi^2(1) = 0.37, p = .10)$
LMS assessment	14	53.9	12	46.2	26	4.5	$\chi^2(1) = 0.01, p = .54)$
Typing Skills	11	45.8	13	54.2	24	4.1	$\chi^2(1) = 0.11, p = .16)$
Netiquette	9	64.3	5	35.7	14	2.4	$\chi^2(1) = 0.68, p = .30)$
Coding	7	63.6	4	36.4	11	1.9	$\chi^2(1) = 1.73, p = .16)$
Data Analytics	3	30	7	70	10	1.7	$\chi^2(1) = 0.36, p = .11)$
Total	274		306		580	100	
% Total	47.2		52.76		100		

Predominant Platforms Used to Teach Children During the Pandemic

During the COVID-19 pandemic, when schools closed for nearly a year, teachers sought alternative instructional media to deliver content to children globally. While educational systems in the West relied on strategic planning and investment in educational technology resources, children in the Global South could not boast of systematic plans to continue learning from their homes. With global health restrictions relaxed since 2021, little is known about teachers' preparedness to meet children's learning goals from homes, should a global health menace reemerge in Sub-Saharan Africa.

Figure 16 shows which digital resources teachers used for instructions during schools' closures in 2020, with 48% (n = 156) indicating social media (WhatsApp) through parents' 3-G phones in Ghana's private and public schools. This was followed by Google resources (19%), Zoom (18.7%), n = 62, radio and television broadcasts (4%, n = 7), and 7% learning management system (LMS) involving CBT, Sakai, and Moodle. Also, only seven private school teachers mentioned CBT deployment, as no government school used LMS. Instructively, 81% (n = 22) government schoolteachers relied on national television and radio lesson broadcast services compared with 19% (n = 5) private school teachers. As private school teachers were prepared to invest in LMS, the same resources were unavailable to public schools during the pandemic.

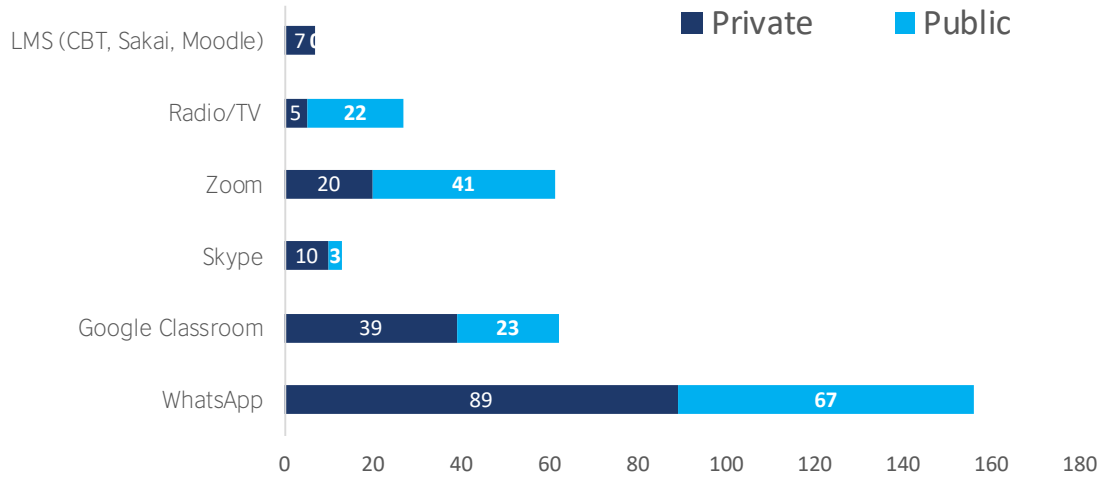


Figure 16. Digital media for children's learning during the 2019 pandemic

Figure 17 also shows the disaggregated digital media deployment for children's education during the pandemic, with the Upper West Region relying more on radio and television than computers used in cosmopolitan (Greater Accra) and metropolitan (Central) areas.

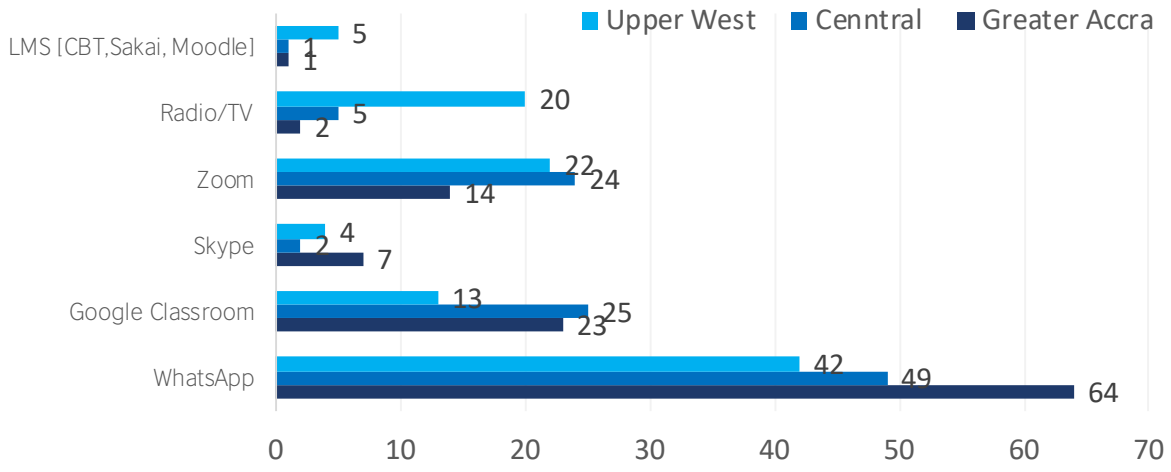


Figure 17. Disaggregated digital media by region

While 85% (n = 580) of teachers shared that they could teach online, 15% (n = 102) responded to the contrary, with 78% (n = 80) from public compared with 22% (n = 22) from private schools. This finding confirmed that more private schools attempted to reach pupils during the pandemic using diverse learning management systems (LMS) and social media platforms.

In Figure 18, male and female teachers' access to digital devices was dominated by 3G technology, followed by personal computers, and even access for male and female teachers due to a government-assisted procurement plan to support teachers' laptops.

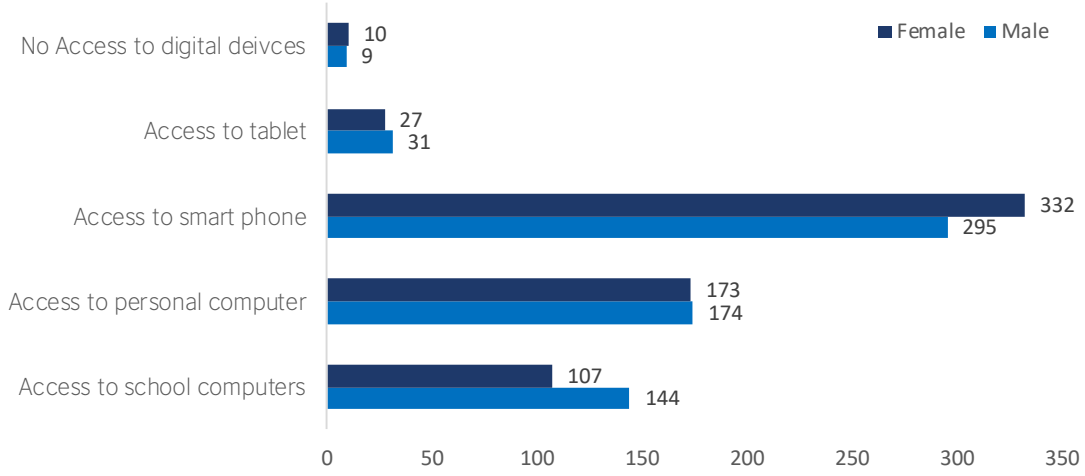


Figure 18. Digital device access for online pedagogical readiness

Juxtaposing this finding with the results in Table 7, technology pedagogical content knowledge (TPACK) interventions are essential for online pedagogy with Ghana's standards-based curriculum framework. The finding equally illustrates a lack of digital resilience for schools; should there be a school disruption, education in marginalised communities will be severely impacted again, while deepening the global learning loss for Sub-Saharan African children.

HA7: *Teachers' tenure will predict differential instruction in mainstream classrooms involving neurodiverse learners.*

Using Kruskal-Wallis' (H) test of variance, we explored the relationship between early-grade teachers' tenure and special needs assessment for differentiated learning. The results were non-significant (H = (2) 1.08, p > .05; 2-tailed) in this study. Also, the small CI (.025) difference for the Monte Carlo estimation indicated a robust value for the iteration between 10,000 and 2,000,000 teachers in this study from a post-hoc perspective. However, in this study, computer access in early grade classrooms had no differential instructional impact (F(3) = 1.26, p = .30) on special needs children's education. The result confirmed the hypothesis that caregivers' tenure had no relationship with their differential assessment techniques, even with over 10 million teachers. The study concluded that the median scores obtained for the Kruskal-Wallis procedure were not statistically different from zero; hence, a pragmatic approach to inclusive didactics in mainstream education should be operationalised beyond Ghana's inclusive education policy.

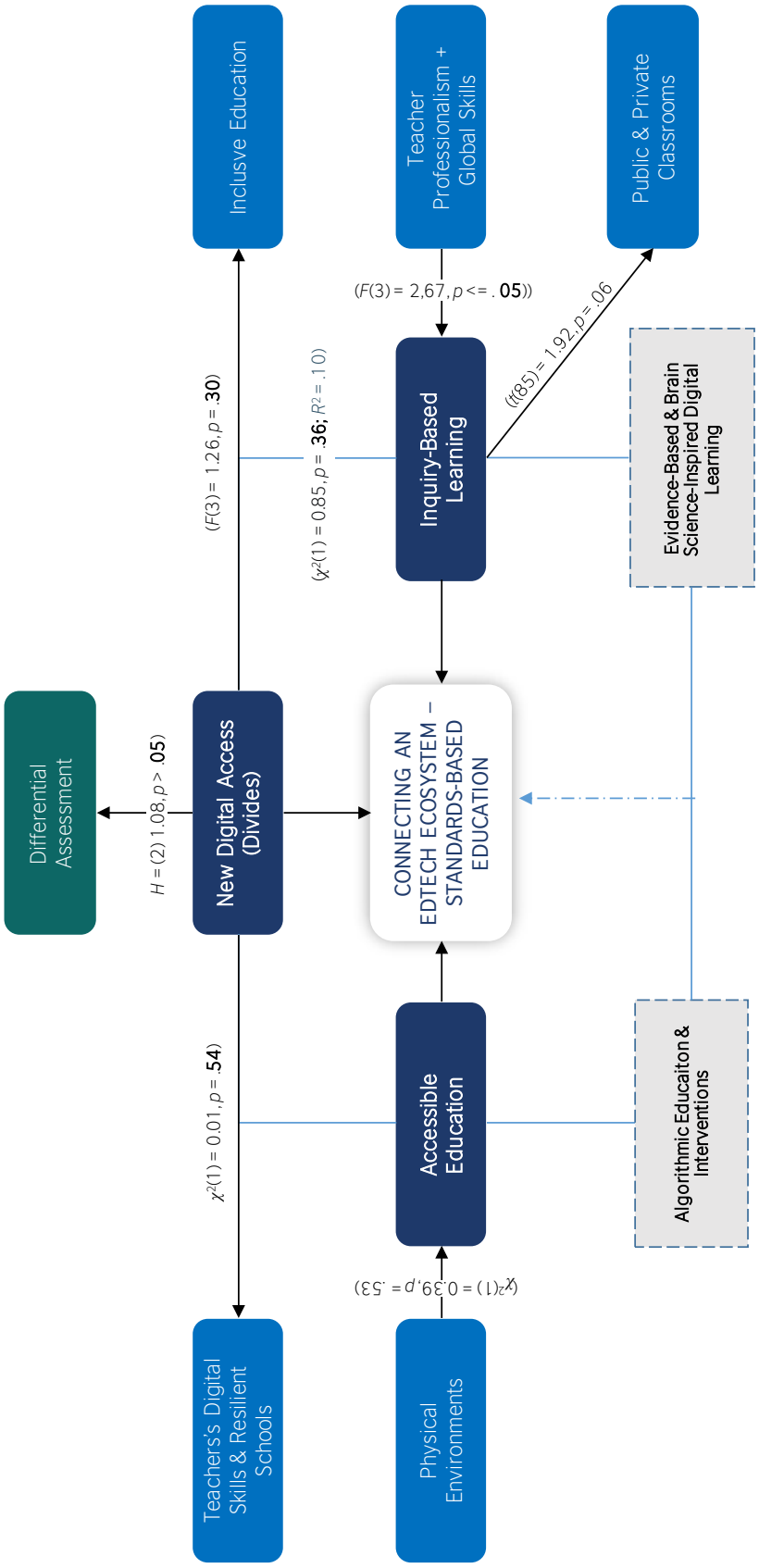
Theory of Change for Resilient Schools and Children's Global Skills

Figure 19 presents the theory of change (ToC) as a strategic framework that explores the learning sciences approach to addressing children's learning loss caused by the COVID pandemic and building resilient schools supporting global skills for education systems in the global South context. The ToC highlights evidence-based digital-supported learning outcomes likely to impact quality education systems and pandemics' disruption to children's learning in marginalised communities. International education stakeholders support vulnerable children in developing sustainable livelihoods in the 21st century. Guided by the literature and experiences during recent school closures globally, the model identified desired impacts of science for knowledge translation under conditions, including marginalisation, digital gap, impoverished school environments, teacher and student digital skills, curriculum reforms, and core competency assessment imperatives for rigorous teacher professional development in developing countries.

Measuring and producing positive impacts on children's learning and development in digital spaces requires significant investments in learning science research, generating evidence-based, interdisciplinary, translational, and reproducible data to guide stakeholders' efforts. The ultimate impact of the Connecting and edtech research ecosystems (CERES) project is viewed from building resilient learning environments for children at home, communities, and formal schools, recognising the impact of generative AI models on quality education delivery. Within the larger framework of CERES, Ghana's study represents a case study for children's education portrait in post-COVID, focusing on digital divides, inequality-based pedagogy, inclusive and accessible learning, algorithmic skills, and developmental psychology needs supporting human-computer interactions (HCI) while impacting edtech product and service delivery.

In addition, the ToC identified prevailing conditions influencing the core CERES's themes through rigorous scientific study over three of the project's life cycles. While several indicators were documented using data visualisation and descriptive statistics (see findings), Figure 19 shares

built models from the field data that generate six core hypotheses for the study. The Discussion section shares the implications of the statistical results for interventions and metrics for tracking and progress evaluation required in education systems for countries of the global majority.



Discussion

An essential consideration of the CERES assignment is to deepen the edtech research ecosystem that supports children and adolescents' learning globally. This consideration stems from the reliance on reports about digital experiences among education stakeholders, thereby missing critical evidence for knowledge translation. Guided by transdisciplinary knowledge from learning scientists, we established that self-reporting questionnaires often produce differential responses from teachers when measuring students' competencies and digital adoption in children's classrooms (Anapey & Aheto, 2022). The study adopted mixed methods to generate an actionable theory of change to address children's learning loss in Sub-Saharan Africa while exploring five themes: digital access, accessible education, algorithmic education and intervention, inquiry-based pedagogy, and brain developmental and brain science-inspired learning.

Our first round of data collection involving classroom, school, and lesson delivery was explored for facilitators in 102 standards-based education systems. Children's core competencies and content standards from STEM-based subjects, including mathematics, science, and ICT, were documented with checklists, as rubrics are the most convenient tools for assessing behavioural traits in context (Johnson & Christensen, 2019). Phase 2 data collection involved a survey of over 800 facilitators who reported their digital adoption levels and gaps for online learning during the pandemic.

The findings indicated a high digital awareness among facilitators despite access disparities for children in public and private schools. While computer availability in schools did not impact inquiry-based learning, including critical thinking, problem solving, and personal development in the mainstream education system, teachers' digital skills for web-based instruction during the pandemic were nonsignificant in this study. The absence of assistive devices for neurodiverse and inclusive pedagogy highlighted the current state of children's digital ecosystems in a Sub-Saharan African nation's education system. The results also showed a high percentage of professionally trained teachers in government schools, and learner-centred activities were not different in private and public schools. Similarly, licensure certification status did not make a difference in creative pedagogy supporting children's 21st-century skills from classroom observation data. Above all, a test of children's digital ecosystem showed weak resilient school structures lacking digital readiness during pandemics in Sub-Saharan Africa.

Key Findings

The summary findings would impact curriculum development, teacher technology professional development, children's global skills and Sustainable Development Goal 4 on quality, gender equity and social

inclusion. Education reform successes include introducing computers in education since Ghana's 2003 ICT4AD policy, followed by the ICT literacy subject on the school timetable from 2007. The data suggest the need to move beyond the generic computer education where children learn 'about' to learning 'with' large language model AI tools, as children are guided to link strands to real-world simulations. For Sub-Saharan schools, the findings also highlight a gap in curriculum reforms' emphasis on introducing multiple subjects for children, with the assumption that teachers are automatically predisposed to deliver the key performance indicators, such as core competencies. Laudable to see competency-based education systems (MBSSE, 202; NaCCA, 2018), but the study revealed an urgent need for learning scientists' support for knowledge sharing that prepares teachers to design rubrics for inquiry-based activities, adopt authentic assessment, learner diagnostics and variability indicators tailored towards children's global skills.

Though teachers are familiar with learner-centred approaches, current learning environments and their low digital tools deprive them of practical group work and play-based learning in early grade classrooms. The results also confirm the NCA's (2020) survey that less than 3% of Ghana's households use computers for productivity, with fewer able to apply spreadsheets and coding skills. While our data shows high social media skills use among teachers, essential digital competencies, including multimedia design, learning management system use, typing, data analytics, and coding skills required to support children's global competencies, were absent in Global South classrooms in this study.

Field Lessons Illustrating Key Results

Field notes align with teachers' inability to access children's core skills despite access to digital tools. In a private school with over 41 functioning computers, our enumerators observed a demonstration of a teacher's inability to integrate the computers into his lesson. The content standard for the day was Simple Levers, a general science subject for Basic Six pupils. Before the teacher entered the computer laboratory to teach the content standard, pupils powered their computers with some using typing, paint, and Microsoft Encarta applications. The teacher entered the class and immediately asked pupils to power off their monitors while he wrote the class activities on the whiteboard after introducing the concepts and learning indicators. The computers were abandoned for pens, exercise books and individual learning. The lesson commences with questioning to elicit relevant previous knowledge and proceeds to sketch a pair of scissors and a wheelbarrow as examples of simple levers, with pupils providing definitions. Pedagogically, the session was dominated by children recalling information from memories instead of exploring various levers on the computer and presenting information as learner-centred pedagogy.

Similar trends were witnessed across different classrooms, with teachers stating the content standards and the precocious pupils recalling textbook answers instead of students constructing knowledge and relating the same to real-world problem-solving scenarios.

The scenario abandoning the PC over

the board manifests teachers' skill gaps for 21st-century instruction and the need for learning sciences discourse on examination systems' impact on sustainable livelihoods for Sub-Saharan African Children. Scientific evidence is required to provide alternatives to the colonial school structures, specialising in children's regurgitation of facts instead of co-creating knowledge, products, and services for entrepreneurial careers in the Fourth Industrial Revolution. School systems must not deprive children of their future in the name of examination instead of dialogic learning. Freire (1993) lucidly refers to the pedagogy of the oppressed and advocates for critical consciousness guided by social and Indigenous knowledge systems. Jonasson's (2004) admonishment for problem-based learning didactics would complement information-seeking curriculum with core competencies.

Imperatives for education research on the African continent include translating specialists' knowledge beyond survey data to knowledge translation spearheaded by child education scientists who themselves can design standards-based lessons combining transdisciplinary knowledge from instructional design, developmental psychology, educational technology, psychometrics, and multimedia labs while protecting children in cyberspace. Likened to the 'theatre of plays', children's classrooms are akin to beehives of activities, parading 'casts' with peers as camera and sound engineers and teachers as co-learners present exciting environments rather than memorising sentences, words, or syllables for self-transformation. UDL and TPACK models present superior pedagogy addressing gender equity and social inclusion, supported by brain science research and developmental psychology for neurodiverse and inclusive education for children in marginalised communities.

Conclusions

The vestiges of the 2019 pandemic have presented practical lessons to education systems as global partners and national governments are concerned about children's learning loss in marginalised societies. While the school's disruption drew attention to digital tools for delivering content for infrastructurally deprived schools, schools in the West quickly became a regular feature of how pupils learn, play and socialise in online environments before COVID-19. Evidence from the study also highlights the plight of children in developing countries playing catch-up to learn on social media platforms such as WhatsApp, and at best, Google Classroom, as COVID-19 shuttered doors to school environments globally to observe social distancing protocols.

With the easing of COVID restrictions, classroom doors have again been opened for learners to reunite with their teachers and peers and socialise in blended mode with increasing technological innovations. However, online resources and tools are often not designed to offer kids and teachers the required support for age-appropriate developmental learning. While the education systems in advanced countries are obsessed with AI models and machine learning, digital games and assistive technologies, with the support of HCI experts working with industry to address the global learning crisis, findings from this study ignite the age-old discourse about weak school structures unsupportive of 21st-century skills for children in marginalised communities.

Essentially, the study answers the primary question: should there be another pandemic today, would Global South children be in school? The empirical findings in Figure 19 point to the contrary, as digital tools had no significant effect on children's global skills. Teachers' low TPACK skills are widening children's learning loss as they continue to learn in standard classrooms instead of digital skills development for competing with peers from the global minority. The results are renditions of Ames's (2019) ethnographic evidence from the OLPC project in Latin America, feeding into our conclusion that even if children's classrooms are stocked with modern AI tools and super computers, findings from this study suggest that children's global skills would not be the focus of learning as classrooms lack rubrics for alternative assessment practices in most marginalised schools in Sub-Saharan Africa. The impact of edtech tools is yet to be evaluated for effectiveness, usability, value for money and benefits using Kucirkova et al.'s (2023) framework while personalising digital tools in early grade schools. Indeed, teacher technology professional development is yet to be part of licensing regimes for many education systems in the global south.

Scientific thinking should be extended to address teachers' capacity to deliver education in plugged and unplugged classrooms. The current data showed that teachers' preparation to teach online and offline using varied digital resources has been compromised

by pedagogical approaches that lack diagnostic tools for learner variability and inclusive education, despite some countries enacting Social Justice policies and laws in Sub-Saharan Africa. While digital access issues could not be overlooked, the data about teachers' capacity to deliver content standards, even with those provided with laptops, was unclear. Practically, the availability of digital devices in schools has low learning integration, as seven global skills observed in over 100 classrooms in Ghana, children's core competencies outlined in the school curriculum, have no relationship with technology adoption. With each cycle of digital innovations, such as AI and machine learning being embraced in the West, children in marginalised communities are impoverished due to a lack of access and teachers' low inquiry-based learning skills to translate content standards into simulations and authentic assessment practices.

Finally, we conclude that as children's learning loss has been partly attributed to COVID-19's disruption to the education system in developing countries, the predictive modelling from HA1 reveals emerging predictors to include learners' inability to benefit from education that uses authentic assessment tools aligned with career profiles for sustainable global skills in the knowledge economy.

Policy and Child Education Science Recommendations

- While contributing to the global discourse on connecting an edtech research ecosystem for children in the post-pandemic era, the significance of the study includes the generation of scientific data to address gender equity, inclusion, access, and disability gaps for children in the Global South. Also, the study would support teachers' technology pedagogical content knowledge practice based on learning science, developmental psychology, and diagnostic assessment practices for dialogic education learning outcomes, inclusive policy briefs, and digital resource utilisation for quality education while leveraging implementation science for research uptake by the global partners in education in marginalised communities.

- The study would advance child education and learning sciences curriculum development, focusing on building simulation laboratories to address children's learning loss using AI solutions in Sub-Saharan Africa.

- As teachers point to national examination structures as contributing to ineffective creative pedagogy in early grade classrooms, examination policy review focusing on alternative assessment practices using digital tools will be essential for children's global skills documentation in Global South education systems.

- While increased funding for childhood research is an imperative for schools, scientists should support knowledge translation through participatory and co-design approaches involving teachers in the learning environments to complement the dominant facilitators' workshops in many Global South education systems. Some developing countries are redesigning teacher licensure regimes to adapt field experiences into in-service teacher training programmes. Findings from this study support teacher-digital integration, UDL, and TPACK models as creative

pedagogical approaches that would provide a foundation for children's 21st-century skills.

- As global partners focus on children's edtech ecosystems, national education standards for teachers, students, and administrators (NETS.s/t/a) must be used to guide global skills assessments for emerging standards-based curriculum in the Global South's education systems as part of teacher licensing regimes. The NETS has the potential to support facilitators and education regulators to address education cross-cutting issues impacting children's global sustainability, including climate change, global citizenship, mental health and resilience, sexuality, environmental sustainability, gender equity and social inclusion, and technology.

- Evidence should be at the heart of Global South nations' education policy and pedagogical practice. Despite the growing popularity of digital tools in various sectors, there remains a notable absence of systematic evidence regarding their effective integration in children's psychological development in developing countries. Traditionally, strands are delivered to children with dichotomous assessment practices of 'right' or 'wrong' answers from children. While examining children's content knowledge is essential, such content must be the fulcrum of children's real-world problem-solving, critical thinking, and co-creation of knowledge in collaborative learning environments. Children working in groups effectively deploy observation, dialogic and questioning processes, events, and facts while engineering prototypes. Standards-based teachers must know the psychology and career profiles to guide differential instruction for neurodevelopment disorders, dyslexia, aphasia and dyscalculia learners. Hence, pre-service pedagogical institutions are required to approach content delivery from transdisciplinary domain knowledge, including developmental psychology, instructional design, multimedia and coding, and psychometrics application to solve learner variability, executive functioning, neurocognition, and career trajectories by guidance and counselling specialists in mainstream classrooms.

- Teacher professional development and assessment leaders in competency-based assessment are imperative for children's global skills using the LMS platform. Children's edtech ecosystem must use diagnostic data for instructional decision-making in the school system.

Declarations

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Ethics approval

This study was guided by an ethical approval number ECH/184/22-23 from the Ethical Committee for Humanity, University of Ghana. All participants gave their consent for participation.

Consent to publish

Participants agreed to use the interview and observation data for publications following our adherence to anonymisation protocols, including integrity, confidentiality, and data protection.

Disclosure Statement

The authors reported no potential conflict of interest.

Data Availability

The data used for analysis will be available on the open-source framework (OSF) hosted by UCI. However, requests can be made to the corresponding author, and data can be released upon reasonable fair use terms established by the principal investigators on behalf of the funding agency.

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Appendices

Appendix A.:
CERES EDTECH CLASSROOM OBSERVATIONS GUIDE

General Information about Research (Verbally share the purpose of the study with the class teacher and seek their consent for the observation exercise).

General Information about Research

The purpose of the study is to explore the children's educational technology ecosystem required for Ghana's standards-based learning outcomes. The study technically documents the new and widening digital divides, accessible education, and computer-supported collaborative learning based on children's developmental psychology at the basic education level. Your participation in this research will provide data that bridges the research in children's educational technology and effective curriculum implementation.

With your consent, the researchers will observe Basic 2, 4, and 6 children's EdTech learning experiences and teacher interviews in your school during STEM lessons. While the study is voluntary, children's confidentiality and safety are protected. The observation is estimated to last 40 minutes, and a 10-minute interview protocol will also be administered to STEM teachers about their pedagogical content knowledge.

Confidentiality

You are assured that your school data will be treated with strict confidentiality and will not be linked to any information or findings. The observation data and interviews will solely be for research purposes.

Compensation

No compensation will be provided.

Withdrawal from Study

Participation in this study is voluntary, and participants may withdraw without penalty. For instance, if school administrators, children and teachers believe their privacy would be compromised, they reserve the right to discontinue the observation process involved in children's classroom digital learning experiences. **Contact for Additional**

Section C- PARTICIPANT AGREEMENT

"I have read or have had someone read all of the above, asked questions, received answers regarding participation in this study, and am willing to consent for me, my child/ ward, to participate. I would not have waived my rights by signing this consent form. Upon signing this consent form, I will receive a copy for my records."

Name of Participant

Signature or mark Participant Date _____

Section A: Background Information

1. Name of Observer
2. Date Stamp
3. Time Stamp (Start)
4. Region
5. District
6. Name of School
7. School Grouping
8. Class
9. Number of Girls (in class)
10. Number of Boys (in class)
11. First Name of Teacher (optional)
12. Teacher's Phone Number (Ethically request the teacher's phone number and email for future training engagement).
13. eacher's Email (Ethically request the teacher's phone number and email for future training engagement).
14. Gender of Teacher
15. Teacher's Highest Qualification
16. The teacher's years of teaching experience
17. Teacher Licensure Status
18. Subject being observed
19. Sub-strand being taught
20. Lesson's learning outcomes (Inspect the lesson note for answers). If not available, report Unobserved below.

GENERAL ICT & SCHOOL ENVIRONMENT

1. Are computers available in the school?
2. Type of ICT ownership
3. Number of functioning computers in the school
4. Categories of learning disorders known to the teacher
5. What assistive devices (aids) are available in the school/classroom?
6. How many special needs children are being observed in the mainstream classroom?
7. A friendly environment for children's learning?
8. Classroom desk arrangement?
9. Teaching and Learning Resources

CLASSROOM/TEACHING OBSERVATIONS

This checklist is an inspection and observation of digital learning experiences that support children's collaborative learning, promote equity, inclusion, access, school interventions, psychological needs in STEM classrooms and Ghana's Standards-based Curriculum (SBC) learning outcomes using a 4-point scale.

3=Effective (The teacher evidenced careful planning and classroom flexibility in implementing the behaviour, eliciting many appropriate student responses. The teacher was clear and sustained focus on the purposes of learning.

2 = Somewhat Effective (The teacher evidenced some planning and/or classroom flexibility in implementing the behaviour, eliciting appropriate student responses. The teacher was sometimes clear and focused on the purposes of learning.

1 = Ineffective (The teacher evidenced little or no planning and/or classroom flexibility in implementing the behaviour, eliciting minimal appropriate student responses. The teacher was unclear and unfocused regarding the purpose of learning.)

N/O= (The listed behaviour was not demonstrated during the time of the observation)

(NOTE: There must be an obvious attempt made for the specific behaviour to be rated "ineffective" instead of "no observed".)

A. Collaborative, Differentiation, Critical Thinking, Problem-Solving, and Conceptual Thinking

2. Provided opportunities for independent or group learning

to promote depth in understanding content.

3. Accommodated individual or subgroup differences (e.g., through individual conferencing, student or teacher choice in material selection and task assignments.
4. Encouraged multiple interpretations of events and situations.
5. employed brainstorming techniques,
6. engaged children in problem identification and definition,
7. engaged children in solution-finding activities, and
8. encouraged children to judge or evaluate situations, problems, or issues,
9. engaged children in comparing and contrasting ideas (e.g., analysing generated ideas)
10. provided opportunities for children to generalise from concrete data or information to the abstract.
11. Encouraged children to synthesise or summarise the information within or across disciplines.
12. Solicited many diverse thoughts about issues or ideas from children
13. engaged in exploring diverse points of view to reframe ideas.
14. Encouraged children to demonstrate open-mindedness and tolerance of imaginative, sometimes playful solutions to problems.
15. Provided opportunities for children to develop and elaborate on their ideas.
16. Instructed/practised concept mapping.
17. Encouraged children's concept modelling and assessment.
18. Applied unit generalisations about cross-cutting/SDGs change.
19. Emphasised relevant concepts, themes, or ideas in the lesson and evaluation.
20. catered for the gifted and the talented, differently
21. attended to learners with learning difficulties and disabilities,
22. managed the different needs of boys and girls,
23. recognised learners with social, emotional and behavioural challenges,
24. addressed marginalised learners (e.g. orphans and vulnerable children, street children)
25. used inquiry-based/dialogic pedagogical approaches.
26. Learner diagnostics practices were systematically documented to inform learning outcomes.
27. Standards-based learning outcomes are clearly articulated to learners.
28. Connected content standards to real-world problem-solving

scenarios for pupils.

29. The Content standard was linked with pupils' career interests.
30. The lesson was presented with digital media resources (multimedia utilisation)
31. Rubrics were used to assess one or more pupils' global competencies
32. Content standard knowledge was evaluated during and after the lesson
33. SDGs informed teacher classroom examples (e.g., climate change, global health, gender, technology, sexuality, sustainability).
34. Demonstrated knowledge about the age developmental needs of children's learning.
35. Utilised digital record systems to inform children's learning in the classroom.
36. Used assistive technology for learners with different disabilities (neurodevelopmental) in the school.
37. Encourage learners to collaborate
38. Sets meaningful tasks that encourage learner collaboration and lead to purposeful learning.
39. Keeps meaningful records of every learner and communicates progress to parents and learners.

B. Classroom Observation Notes

1. To the class teacher (Can this lesson be taught in the computer laboratory?
2. Explain your answer in 1 above

C. Competency-Based Assessment

Overall assessment of children's digital resources, collaborative learning, teacher TPACK, interventions, psychological needs, guidance and counselling services,

1. Critical thinking
2. Problem solving
3. Innovation
4. Cultural identity
5. Global citizenship
6. Personal development
7. Leadership
8. Digital Literacy

9. The observed lesson was assessed by...
10. Class work
11. Homework
12. verbally assessed
13. Group work
14. Project work
15. Internet/treasure hunt activities
16. Overall assessment of children's digital resources, collaborative learning, teacher TPACK, interventions, psychological needs, guidance and counselling services.
17. Did you observe children asking questions during the lesson?
18. Did the teacher encourage children to pose varied questions?
19. General school environment observation (Disability structures, sanitary conditions, classroom, furniture, computer lab, compound, etc.)
20. Exit time (Thank the class teacher and exit)

Appendix B.
Teacher Pandemic Readiness and Online Teaching Skills Survey

Rotated Component Matrix[a]

		LMS Readiness
1	I can securely report grades to students and input final grades into the University's grading system as required.	.993
2	I can mediate course-related student conflicts in accordance with my institution's policies.	.969
3	I can obtain technical assistance and support for either myself or my students at the appropriate time.	.924
4	I can continuously monitor and manage children progress by using course statistic to identify who are not accessing course materials, participating in learning activities, and reach out to engagement them.	.906
5	I can create multimedia contents to meet diverse learning styles in my classroom.*	.88
6	I can communicate my expectations about student behaviours in my course (i.e., netiquette).	.872
7	I can provide a comprehensive syllabus that adheres to my institution's policies. The syllabus includes a course examination policy, a basis for grades, an academic integrity policy, and a disability access statement.	.863
8	I am familiar with the unique learning needs of my pupils using learner diagnostic assessment tools.	.851
9	I can communicate and monitor compliance regarding institutional academic integrity policies.	.845
10	I actively participate in the course through a variety of communication tools.	.844
11	I can provide detailed feedback on assignments and exams through facilitation, guidance, directed learning, and progress assessment.	.815
12	I can notify students through a variety of communication tools when I am unavailable to participate in course-related activities.*	.797
13	I can respond to pupils' inquiries within 12-24 hours to guide students towards a positive learning outcome.	.775
14	I can achieve mastery of the teaching and learning in online environments by becoming familiar with all course materials, structure, and organization of the course environment.	.772
15	I can promote and encourage a safe, inviting, and mutually respectful learning environment by communicating with children in a positive tone and by following and promoting Netiquette guidelines.	.75
16	I can demonstrate sensitivity to disabilities and diversities, including aspects of cultural, cognitive, emotional, and physical differences.	.745
17	I communicate to students when assignments and exams will be graded and returned per assignment/quiz/exam.	.734
18	As needed, I can revise course content and instructional materials based on student feedback.	.654
19	I can communicate course goals and outcomes using the syllabus and course announcements at the beginning of online learning.	.561
20	I can communicate as needed with children about online course progress and changes via email, announcements, chats, and WhatsApp.	.535
21	I can establish my presence in the course on a regular basis via course announcements, assignments, emails, online office hours, and various other methods.	.511
22	I can adhere to the institutional policies regarding the Federal Educational Rights & Privacy Act (FERPA).	.488
23	14. I can teach my pupils online using synchronous and asynchronous tools	.089
	Extraction Method: Principal Component Analysis.	
	Rotation Method: Varimax with Kaiser Normalization.	
	a. Rotation converged in 5 iterations.	

Background Information:

- Gender
- Region
- School Grouping (Public/Private)
- Class teach
- Licensure Status
- Access to school computers, personal computer, smart phone, tablet

Appendix C.
Classification Table a,b For Hypothesis 1 (HA1)

Classification Table[a]

Observed			Predicted		
			Computer Availability		Percentage Correct
			Not Available	Available	
Step 1	Computer Availability	Not Available	48	11	81.4
		Available	27	16	37.2
	Overall Percentage				62.7

a. The cut value is .500

Appendix D. Variables in the Equation for HA1

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Problem Solving	-.298	.372	.642	1	.423	.742
	Critical Thinking	-.451	.590	.584	1	.445	.637
	Creativity	-.113	.517	.048	1	.826	.893
	Conceptual Thinking	1.188	.788	2.274	1	.132	3.280
	Inclusive Education	-.611	.817	.559	1	.455	.543
	Differentiation	-.674	.862	.610	1	.435	.510
	Creative Pedagogical Knowledge	1.277	.631	4.091	1	.043	3.586
	Constant	-.757	.819	.854	1	.355	.469

a. Variable(s) entered on step 1: Problem Solving, Critical Thinking Skills, Creative Thinking Skills, Conceptual Thinking, Inclusive Education, Psychological Development Knowledge, Creative Pedagogical Knowledge.

Appendix E:
Multiple comparisons for HA1

	(I) Exempted, written, unqualified, and yet to sit categories -4	(J) Exempted, written, unqualified, and yet to sit categories -4	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	Exempted	Written	-.28758*	.12384	.022	-.5334	-.0418
		Yet to Attempt	.01895	.13155	.886	-.2421	.2800
		Unqualified	.05258	.14293	.714	-.2311	.3363
	Written	Exempted	.28758*	.12384	.022	.0418	.5334
		Yet to Attempt	.30653*	.13886	.030	.0309	.5821
		Unqualified	.34016*	.14969	.025	.0431	.6373
	Yet to Attempt	Exempted	-.01895	.13155	.886	-.2800	.2421
		Written	-.30653*	.13886	.030	-.5821	-.0309
		Unqualified	.03363	.15613	.830	-.2762	.3435
	Unqualified	Exempted	-.05258	.14293	.714	-.3363	.2311
		Written	-.34016*	.14969	.025	-.6373	-.0431
		Yet to Attempt	-.03363	.15613	.830	-.3435	.2762

*. The mean difference is significant at the 0.05 level.
Dependent Variable: Pedagogical Approaches

Appendix F: Inquiry Based Learning for Neurodiverse Children

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
						Lower Bound	Upper Bound			
1.00 (2-months – 5-years		37	1.7230	.41643	.06846	1.5841	1.8618	1.00	3.33	
2.00 (6-years to 10-years)		34	1.9240	.53713	.09212	1.7366	2.1114	1.06	3.35	
3.00 (11-years to 15-years		23	1.9384	.67740	.14125	1.6455	2.2313	1.00	3.42	
Total		94	1.8484	.53703	.05539	1.7384	1.9584	1.00	3.42	
Model	Fixed Effects			.53307	.05498	1.7392	1.9576			
	Random Effects				.07239	1.5370	2.1599			.00641

Appendix G: Independent t-test for Classroom Collaborative Pedagogy for HA5

		Levene's Test for Equality of Variances		t-test for Equality of Means					
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	SE Diff.	95% CI of the Difference
									Lower / Upper
Creative/inquiry-based Pedagogical Approaches	Equal variances assumed	6.328	.013	-1.84	100	.068	-.179	.097	-.372 / .014
	Equal variances not assumed			-1.93	85.37	.057	-.179	.093	-.364 / .006

Appendix H: Children Creative Learning Approaches

#	Instruction	Mean Score	SE	SD
1	Engaged children in concept/sub-strand identification and definition.	2.54	0.104	1.05
2	Content standard knowledge was assessed during and after lesson.	2.52	0.099	1.002
3	Engaged children in solution-finding activities.	2.48	0.103	1.03
4	Emphasis relevant concepts, themes, or ideas in lesson and assessment.	2.47	0.110	1.11
5	Engaged children in the exploration of diverse points of view to reframe ideas.	2.44	0.099	1.001
6	Encouraged children to demonstrate open-mindedness and imagination with solutions to problems.	1.96	0.095	0.964
7	Provided opportunities for children to develop and elaborate on their ideas.	1.95	0.095	0.958
8	Employed brainstorming techniques	1.92	0.105	1.059
9	Provided opportunities for independent or group learning to promote depth in understanding content	1.78	0.102	1.026
10	Connected content-standards to real-world problem-solving scenarios for pupils.	1.62	0.075	0.758
11	Attended to learners with learning difficulties and disabilities	1.58	0.1	1.009
12	Standards-based learning outcomes clearly articulated to learners.	1.58	0.081	0.814
13	SDGs informed teacher classroom examples (e.g., climate change, global health, gender, technology, sexuality, sustainability etc.).	1.55	0.078	0.781
14	Sub-strands linked with children career interests.	1.24	0.061	0.616
15	Learner diagnostics practices were systematically documented to inform learning outcomes.	1.17	0.052	0.528
16	Encouraged children concept modelling skills.	1.11	0.044	0.445

n = 102

Dessimination of CERES in Freetown, Serral Leone

Co-design approach with early grade teachers about inquiry-based pedagogy in Ghana's schools

Supporting inclusive education in Ghanaian school

CERES scholars

College of Education, Provost received the CERES' director, training and development


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