Specialized Subject Laboratories and Implementation of Science and Computer Studies Curriculum in Public Junior Schools in Narok County, Kenya

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Abstract

The implementation of Kenya's Competency-Based Curriculum (CBC) depends on access to specialized laboratories that support practical, learner-centered pedagogy in science and computer studies. This study examines how laboratory availability influences CBC implementation in public Junior Secondary Schools in Narok County. Using a cross-sectional mixed-methods design, data were collected from 25 schools across three sub-counties. Quantitative analysis revealed that most schools lacked adequate laboratory infrastructure, relying on improvised setups. Teachers cited laboratory shortages as a major barrier to effective curriculum delivery, while learners reported limited engagement in practical activities. Correlation analysis showed a significant relationship between laboratory availability and CBC implementation from teachers' perspectives, but not from learners. Qualitative insights confirmed gaps in equipment, reagents, and ICT integration. The study concludes that infrastructural deficits undermine CBC goals and recommends targeted investment in laboratory construction, virtual labs, teacher training, and public-private partnerships to enhance inquiry-based learning and equip learners with 21st-century competencies.

Keywords: Competency-Based Curriculum, Specialized Laboratories, Virtual Laboratories, Junior Secondary Schools

Introduction

The Competency-Based Curriculum (CBC) adopted in Kenya places practical, learner-centred pedagogy at the centre of basic education and explicitly foregrounds competencies in science, technology and digital literacy (Kenya Institute of Curriculum Development [KICD], 2017). Under the CBC the role of Junior Schools shifts from transmission of facts to development of inquiry, problem-solving and technological competencies that require access to appropriate learning environments and equipment (Ministry of Education, 2019). Ensuring that learners gain experience with hands-on science tasks and digital tools therefore depends in large part on whether schools can provide and sustain specialised subject laboratories for science and for computer studies.

Extensive research in science education has long identified the laboratory as a central site for developing conceptual understanding, scientific reasoning and affective outcomes such as curiosity and motivation (Hofstein & Lunetta, 2004; Lunetta, Hofstein, & Clough, 2007). Recent systematic reviews of practical work and laboratory research confirm these claims while adding important qualifications: practical activities produce learning gains mainly when tasks are well designed, aligned with learning outcomes and supported by skilled teacher facilitation and suitable assessment practices (Oliveira & Bonito, 2023; Gericke, Högström, & Wallin, 2023). In short, the mere presence of a room labelled 'laboratory' is insufficient; impact depends on the condition of equipment, the pedagogical design of activities, and teachers' capacity to orchestrate inquiry-based learning.

For computer studies, access to functional computer laboratories is essential not only for basic ICT skills but also for collaborative, project-based and problem-solving activities aligned with 21st-century competencies (Voogt, Knezek, Christensen, & Lai, 2017). International evidence from low- and middle-income settings highlights a persistent rural–urban divide in ICT readiness: infrastructure, reliable electricity and internet, sustainable maintenance, and ongoing teacher professional development are all necessary enablers of meaningful digital learning (Voogt et al., 2017; Ngeno, Mweru, & Mwoma, 2021). Where these enablers are missing, computers remain under-utilised and do not yield the competency gains envisaged by curriculum reforms.

Kenya's policy environment has recognised these gaps and in recent years signalled renewed investment in laboratories and infrastructure. Official curriculum documents reiterate the need for appropriate physical resources to implement CBC, while recent national planning documents and donor-supported programs (for example, SEEQIP) emphasise systems strengthening to improve equitable access and quality (Ministry of Education, 2019; The World Bank, 2024). At the same time, county-level empirical studies in Kenya show that shortages of physical infrastructure are already constraining CBC implementation in practice: for example, Kericho County studies report that lack of equipment and facilities negatively affects teachers' ability to deliver practical lessons (Ngeno et al., 2021). National press coverage and government announcements (November 2024) about plans to construct labs illustrate political intent, but these initiatives raise implementation questions (resourcing, maintenance, access for Junior Schools) that merit empirical scrutiny at the school level.

Despite wide agreement that specialised laboratories matter, the literature still contains important gaps relevant to Kenya's CBC rollout. Many studies of laboratory and ICT effects focus on secondary or higher education, provide descriptive accounts of infrastructural deficits, or treat 'infrastructure' as one variable among many without isolating its direct influence on specific CBC learning areas in Junior Schools (Gericke et al., 2023; Oliveira & Bonito, 2023). There is therefore a need for focused, mixed-method inquiry that examines how the availability, condition and pedagogical integration of specialised subject laboratories shape the actual implementation of science and computer studies in Junior Schools in rural counties such as Narok. This study addresses that gap by investigating the relationship between laboratory provision, teachers' pedagogical practices and learners' engagement and performance in CBC-aligned science and computer studies.

Statement of the Problem

The CBC emphasizes learner-centred pedagogy and practical exposure, particularly in science and computer studies (KICD, 2017). Laboratories are critical for fostering hands-on learning, problem-solving, creativity, and innovation skills (Wanjohi, 2022). Yet, many public Junior Schools face resource constraints, raising concerns about the adequacy of infrastructure to support implementation of CBC (Oduor, 2023). This study investigates the extent to which specialized subject laboratories influence the implementation of science and computer studies in Narok County.

Research Questions

- To what extent are specialized science and computer studies laboratories available in public Junior Schools in Narok County?
- How does the availability of specialized subject laboratories influence the implementation of the competency-based curriculum in science and computer studies?
- What challenges do schools face in utilizing laboratories and ICT resources for effective implementation of science and computer studies under CBC?

Literature Review

The implementation of Kenya's Competency-Based Curriculum (CBC) emphasizes learner-centered, practical, and technology-supported pedagogies, particularly in science and computer studies. Laboratories—both physical and digital—play a critical role in fostering hands-on learning, problem-solving, creativity, and innovation skills. Despite policy ambitions, many public Junior Schools face resource constraints, raising concerns about the adequacy of infrastructure to support CBC goals. This section critically examines the literature on laboratory provision, ICT integration, teacher capacity, and equity considerations in the context of science and computer education in Kenya. It identifies gaps and justifies the focus of the present study on Junior Schools in Narok County.

Laboratories and the Pedagogical Promise of Practical Work

Laboratories have long been recognized as central to science education because they enable inquiry-based, experiential learning that bridges theory and practice (Hofstein & Lunetta, 2004; Lunetta, Hofstein, & Clough, 2007). Practical work enhances conceptual understanding, procedural knowledge, scientific reasoning, and affective outcomes such as curiosity and motivation (Gericke, Högström, & Wallin, 2023; Oliveira & Bonito, 2023).

Recent reviews underscore that the strongest learning gains occur when laboratory activities are deliberately aligned with curriculum objectives and supported by facilitative teacher strategies (Gericke et al., 2023).

Oliveira and Bonito (2023) further argue that tasks must be embedded within a coherent sequence and assessed appropriately. Harder (2024) highlights that the mere presence of a laboratory is necessary but insufficient for pedagogical effectiveness. These findings suggest that laboratories are not just spaces for experimentation but are pedagogical tools whose impact depends on quality of design, teacher facilitation, and integration into learning objectives.

Computer Laboratories Digital Literacy and Socio-Technical Constraints

Computer laboratories provide environments for digital skill acquisition, collaboration, and problem-solving (Voogt et al., 2017). However, their effectiveness depends on reliable electricity, internet connectivity, maintenance regimes, localized content, and teacher professional development (Voogt et al., 2017; World Bank, 2024).

Research in East Africa reveals persistent rural-urban divides in ICT literacy, where under-resourced schools experience limited connectivity, inadequate teacher skills, and underutilization of computers for rote learning rather than higher-order cognitive tasks (Ngeno, Mweru, & Mwoma, 2021). These socio-technical constraints illustrate that access alone is insufficient; contextualized support and capacity-building are essential for effective ICT integration.

ICT Integration and the Competency-Based Curriculum

Kenya's CBC emphasizes learner-centred, competency-driven approaches that rely on practical learning supported by digital technologies (KICD, 2019 & Ministry of Education, 2019). ICT serves as both a subject and a cross-cutting tool to facilitate innovation and problem-solving. Studies show that teacher attitudes, perceived usefulness, access to infrastructure, and training significantly influence ICT integration (Murithi et al., 2021; Opondo et al., 2023; Mutisya, 2020).

While policy documents stress ICT adoption, teacher readiness and institutional support remain uneven, limiting its implementation. These findings reinforce the need to consider both infrastructural and human capacity factors in evaluating ICT-enabled pedagogy.

Virtual Laboratories Adoption: An Alternative to Specialized Subject Laboratories

The Competency-Based Curriculum (CBC) in Kenya emphasizes experiential and practical learning, especially in science and computer studies (KICD, 2017). However, many schools face infrastructural limitations, particularly the absence of specialized laboratories. In response to these challenges, virtual laboratories (VLs) have emerged globally as a viable alternative. These platforms offer simulated environments that enable practical engagement without the need for physical infrastructure (De Jong, Linn, & Zacharia, 2013).

Virtual laboratories are interactive, computer-based tools that replicate the functions of physical labs. They allow learners to conduct experiments, manipulate variables, and observe outcomes in a controlled digital space (PraxiLabs, 2025a). Their key benefits include accessibility, cost-effectiveness, safety, and scalability. VLs can be accessed via mobile devices, reducing dependence on physical space and equipment. This eliminates the need for expensive lab setups and consumables, while also allowing students to explore hazardous experiments without physical risk (Kimuge, 2021).

Despite these advantages, the effectiveness of VLs in Kenyan schools is constrained by the digital divide. Many institutions, especially in rural areas struggle with limited internet connectivity, inadequate ICT infrastructure, and uneven teacher preparedness (PraxiLabs, 2025b & UNESCO, 2023). These barriers hinder the full integration of VLs into CBC-aligned teaching and learning.

Studies from countries such as India, South Africa, and the United States demonstrate that VLs enhance conceptual understanding in STEM subjects. Research by De Jong et al. (2013) shows that VLs support inquiry-based learning and critical thinking. In low-resource settings like Kenya, VLs have also been shown to democratize access to quality science education (Khan, Ahmad, & Malik, 2021).

To this end, Kenya's Ministry of Education should prioritize the integration of virtual laboratories into its Junior School science and computer studies curriculum. This effort must be supported by investments in digital infrastructure, teacher training, and equitable access to devices and connectivity especially in underserved regions.

Recent initiatives reflect growing interest in VLs in Kenya. For example, in Wajir County, over 100 junior schoolteachers were trained on virtual labs through a partnership between the Ministry of Education and the Centre for Mathematics, Science, and Technology Education in Africa (CEMASTEA). This program aimed to enhance STEM education and support CBC implementation (Kenya News Agency, 2023). CEMASTEA has also rolled out digital resources, including virtual labs, designed to be inclusive, engaging, and aligned with CBC goals (Education News Hub, 2023).

Nonetheless, implementation challenges persist. Many schools lack reliable internet and sufficient devices (Kimuge, 2021). Effective use of VLs requires digital literacy and pedagogical training for teachers. VLs must also be tailored to CBC standards and learning outcomes to ensure relevance and usability.

Additionally, rural and marginalized schools may lag in access and implementation of VLs. Hence, targeted investments in digital infrastructure, teacher training, and equitable access to devices and connectivity are essential. These measures will ensure that virtual laboratories benefit all learners in Kenya's Junior Schools, regardless of geographic or socioeconomic barriers. When properly integrated, VLs can help mitigate the shortage of specialized laboratories and enhance CBC delivery across the country,

Kenya's Policy Intentions Versus On-the-Ground Realities

National policies and international initiatives signal investments in laboratory infrastructure and ICT expansion, aiming to improve equity and quality in science and computer education (World Bank, 2024; Ministry of Education, 2019). However, empirical evidence reveals substantial implementation gaps. Many Kenyan schools, especially in rural areas, lack purpose-built facilities, adequate equipment, reagents, and maintenance support (Mulinge, 2017; Ngeno, Too, & Kimutai, 2021). Consequently, teachers often revert to teacher-centered approaches in the absence of practical resources. Urban schools, in contrast, are more likely to have well-resourced facilities, highlighting inequities in access (Ngeno, Mweru, & Mwoma, 2021).

Teacher Capacity and the Technology Acceptance Model

The Technology Acceptance Model (TAM) offers insight into teachers' adoption of laboratory and ICT-enabled practices (Davis, 1989). Teachers are more likely to use these tools effectively when they perceive them as both useful and easy to use. Barriers such as inadequate training, maintenance challenges, and time pressures reduce adoption and pedagogical impact (Opondo et al., 2023; Murithi et al., 2021). Evidence suggests that sustained pedagogical change requires continuous, contextualized professional development combined with institutional support. Thus, laboratory availability alone is insufficient; teacher capacity is critical for realizing CBC objectives.

Equity Sharing Models and Sustainability

To improve access, policy proposals advocate shared facilities, including district or cluster laboratories. Shared models offer advantages such as cost efficiency and access to specialist staff but also present logistical and equity challenges, including transport costs, scheduling conflicts, and concentration of resources in urban centres (Harder, 2024; Baumüller, 2016). Sustainable laboratory provision requires governance structures, maintenance funding, and monitoring frameworks to prevent disparities and ensure equitable access.

Gaps and Justification for the Present Study

Despite substantial international literature on laboratory pedagogy and ICT integration, significant gaps persist. Most studies focus on secondary or higher education, Junior Schools while under CBC under-studied because it is a relatively new phenomenon in Kenya. Furthermore, few studies disaggregate infrastructure variables into existence, condition, accessibility, and pedagogical integration (Opondo et al., 2023 and Mutisya, 2020). This study addresses these gaps by examining public Junior Schools in Narok County, focusing on how laboratory provision, pedagogical practices, and learner engagement interact under CBC implementation. The conceptual framework is presented in figure 1.

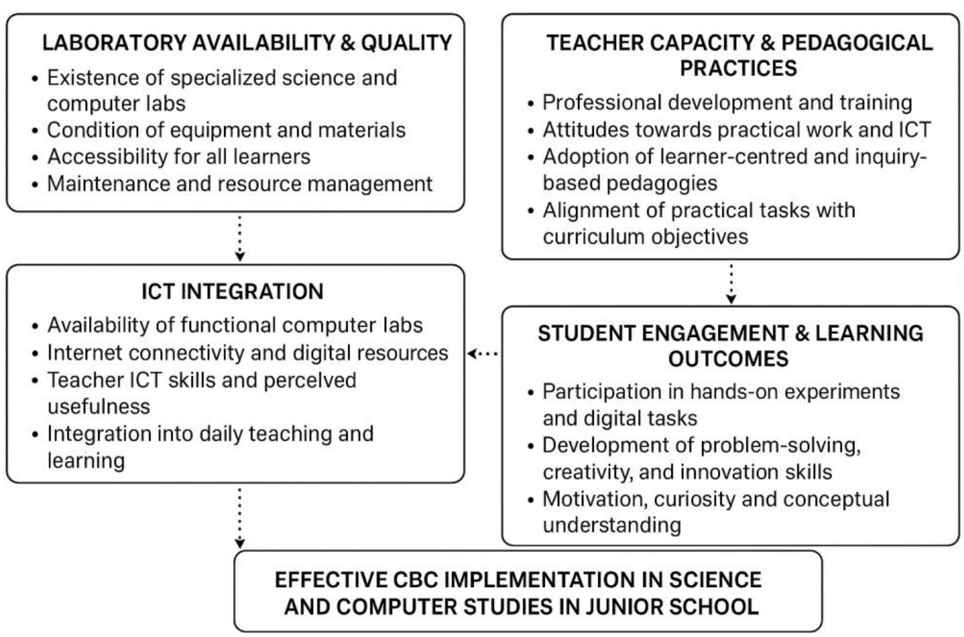

Figure 1: Conceptual Framework

The framework portrays a causal relationship where well-equipped laboratories and capable teaching foster better ICT integration and learning experiences, ultimately supporting successful curriculum implementation.

Methodology

The study employed a cross-sectional mixed-methods design, integrating quantitative and qualitative approaches to explore the influence of specialised subject laboratories on the implementation of science and computer studies under the Competency-Based Curriculum (CBC) in public junior schools. This design was chosen because it allows systematic description of existing conditions and analysis of relationships between variables without manipulation (Wang & Cheng, 2020 and Creswell, 2022). The research was conducted in Narok County, Kenya, a rural urban county with eight sub-counties and 662 public Junior Schools (KNBS, 2020). The target population comprised 662 head teachers, 1666 teachers, 64654 learners (Grades 7–9) and 8 Sub-County Quality Assurance and Standards Officers (SCQASOs).

Sampling Procedure

This study used a multi-stage sampling procedure to progressively narrow the population into representative groups. First, sub-counties and schools offering Grades 7–9 were identified, with SCQASOs included as a census. Then, head teachers, teachers, and learners were sampled proportionately and stratified to ensure diversity and balance across the large population (Creswell, 2022). Three sub-counties (30% of the total) were selected using simple random sampling (Mugenda & Mugenda, 2013). Within these, 25 schools (10%) were sampled through stratified random techniques to ensure proportional representation. All 25 head teachers and 84 class teachers were purposively included, given their manageable numbers and direct role in CBC implementation. Learners ($n = 394$) were selected using Yamane's (1967) formula and stratified random sampling used to capture all grades and streams. Additionally, three SCQASOs (one from each sub-county) were purposively included.

Data Collection Instruments

Teachers Questionnaires and learners Questionnaires with sections on demographics, availability of laboratories and CBC implementation were used to collect data. Semi-structured interviews for head teachers and SCQASOs were used to explore perceptions of infrastructural adequacy and pedagogical practices while observation checklists were used to document the physical condition and utilization of laboratories.

Validity and Reliability

Instrument validity was enhanced through expert review, piloting in five schools, and triangulation across respondent categories. Reliability was established using Cronbach's alpha ($\alpha \geq 0.7$), test–retest correlation ($r \geq 0.7$), and inter-rater reliability via Cohen's kappa ($\kappa \geq 0.8$) (McHugh, 2017; Creswell, 2022).

Data Analysis

Quantitative data were analysed using SPSS v30. Descriptive statistics (means, SDs, frequencies) summarised trends, while Pearson's correlation tests examined relationships between laboratory availability and CBC implementation. Statistical significance was set at $p < 0.05$. Qualitative data from interviews and observations were transcribed, coded, and thematically analysed to complement and contextualise quantitative results (Braun & Clarke, 2019).

Ethical Considerations

Ethical approval was obtained from relevant authorities. Participants provided informed consent, confidentiality was maintained, and learner assent was sought. Schools involved in piloting were excluded from the main study to avoid bias.

Results and Discussion

This section presents, interprets and discusses the study's findings in line with the study Research Questions namely:

- To what extent are specialized science and computer studies laboratories available in public Junior Schools in Narok County?
- How does the availability of specialized subject laboratories influence the implementation of the competency-based curriculum in science and computer studies?
- What challenges do schools face in utilizing laboratories and ICT resources for effective implementation of science and computer studies under CBC?

The section begins with the response rate and demographic information, followed by detailed results on laboratory availability, implementation of science and computer studies, correlation analysis, and qualitative insights. Each section integrates findings with interpretation and discussion based on relevant literature.

Response Rate

All teachers and learners completed and returned the questionnaires, yielding a 100% response rate in both groups. A 100% response rate enhances the reliability and validity of the findings (Mugenda & Mugenda, 2003).

Demographic Information of Participants

The demographic information collected covered head teachers, teachers, learners, and Sub-County Quality Assurance and Standards Officers (SCQASOs). Table 1 presents a consolidated summary of these demographics.

Table 1: Demographic Information

Participant Group	Characteristic	Category	Frequency (%)
Head Teachers	Gender	Female	3 (21.4)
	Gender	Male	11 (78.6)
Teachers	Gender	Female	50 (59.5)
	Gender	Male	34 (40.5)
Learners	Gender	Female	208 (52.8)
	Gender	Male	185 (47.0)
SCQASOs	Gender	Male	2
	Gender	Female	1

The demographic data revealed that head teacher positions were male dominated (78.6%). Teachers were mostly young, with 89.3% under 40 years, suggesting energy and openness to innovation, but limited experience. Learners were evenly distributed by gender, though nearly 30% were older than expected for their grade, indicating possible repetition or delayed entry. SCQASOs were few, limiting oversight capacity.

Availability of Specialized Subject Laboratories

Teachers and learners rated the availability of specialized laboratories for science and computer studies. Both groups reported low availability, though learners rated availability slightly higher.

Table 2: Availability of Specialized Subject Laboratories (Teachers)

Item	N	Min	Max	Mean (SD)
School has science labs	81	0	4	0.938 (1.076)
School has computer lab	82	0	3	0.671 (0.771)
Labs adequate for CBC	80	0	3	0.650 (0.731)

Table 3: Availability of Specialized Subject Laboratories (Learners)

Item	N	Min	Max	Mean (SD)
School has science labs	384	0	4	1.521 (1.188)
School has computer lab	387	0	4	0.913 (1.094)
Labs adequate for CBC	388	0	4	1.043 (0.777)

Overall, both teachers ($M = 0.74$) and learners ($M = 1.21$) rated laboratory availability as low. This finding suggests significant gaps in infrastructure, limiting opportunities for practical learning. Studies show that specialized labs are essential for skill development in science and technology (Mulinge, 2017; World Bank, 2024).

Correlation Between Laboratory Availability and Implementation of CBC

Composite scores were correlated to assess the influence of labs on implementation (Table 4).

Table 4: Relationship between Availability and Implementation of CBC

Group	R	P-value
Teachers	0.422	<0.001
Learners	0.011	0.820

The results revealed a moderate positive and statistically significant relationship between the availability of CBC resources and its implementation among teachers ($r = 0.422$, $p < 0.001$). This indicates that increased availability of resources is associated with greater implementation of the curriculum by teachers. In contrast, the relationship between availability and implementation among learners was negligible and not statistically significant ($r = 0.011$, $p = 0.820$), suggesting that resource availability does not directly influence learners' uptake of CBC, possibly reflecting limited awareness of curriculum implementation standards.

Qualitative Insights from Interviews

Interviews with head teachers and SCQASOs revealed critical gaps in resource availability and curriculum implementation. Two main themes emerged: (1) resource inadequacies and (2) implementation gaps. Many schools relied on 'portable laboratories,' where science equipment was stored in offices or small rooms and transported when needed. As one head teacher noted, *"Most schools have embraced mobile labs. Science equipment is there, but no rooms to keep them. So, they are kept in the head teacher's office."*

However, even these portable labs were inadequate. SCQASOs highlighted that while some schools had basic equipment, they lacked reagents and consumables for meaningful practical work: *"A number of Junior Schools have portable laboratories with basic science equipment. However, there are no accompanying reagents to enable meaningful practical work. The portable labs are mostly used for demonstrations, and not real practical work."* (SCQASO 2).

ICT integration also faced challenges. Despite learners having tablets, teachers often relied on theory rather than practical application. One SCQASO observed: *"Learners use tablets, which almost 90% of them have. However, ICT integration has not been fully implemented. There are no computer labs. Teachers mostly use theory. They are not even willing to use their mobile phones to aid learning."* (SCQASO 3).

These findings suggest that while some infrastructure and equipment exist, their inadequacy and underutilization limit effective CBC implementation. Similar concerns have been reported in prior research, where teachers' lack of confidence or skills often led to low utilization of ICT resources (Opondo et al., 2023). Thus, qualitative evidence strongly reinforces the quantitative findings: specialized laboratories are insufficient, and their absence undermines the full implementation of science and computer studies in Narok County Junior Schools.

Conclusion

This study confirms that the availability of specialized laboratories significantly influences the implementation of science and computer studies under Kenya's CBC. Teachers' responses highlight the critical role of infrastructure in delivering practical, competency-based education, while learners' limited awareness signals a need for deeper engagement. Without adequate facilities, CBC goals remain aspirational.

Recommendations

To strengthen the implementation of science and computer studies under Kenya's Competency-Based Curriculum (CBC), particularly in public Junior Secondary Schools, the following actions are recommended:

- Government Prioritize the construction and equipping of specialized science and computer laboratories in underserved schools.
- Government to expand access to reliable internet, electricity, and devices to support the adoption of virtual laboratories, especially in rural and marginalized regions.
- Ministry of education to provide continuous, context-specific professional development for teachers on ICT integration and virtual lab usage aligned with CBC goals.

- Ministry of Education to empower Sub-County Quality Assurance and Standards Officers (SCQASOs) with resources and training to monitor laboratory utilization and support schools in optimizing available resources.
- Government to encourage collaboration with NGOs, tech companies, and development partners to co-fund laboratory infrastructure, digital tools, and teacher training programs.
- Kenya Institute of Curriculum Development to ensure that virtual laboratory platforms are aligned with CBC learning outcomes and accessible on low-bandwidth devices to maximize usability across diverse school contexts.
- Ministry of Education to adopt a needs-based approach to resource distribution, ensuring that schools in remote and low-income areas receive priority support to close the digital and infrastructural divide.

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