Using Local Materials for Inquiry: Upper-Primary Teachers' Knowledge and Perceived Constraints on Improvisation for Science Teaching in Ghana

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Abstract

The use of improvised instructional materials has the potential to extend prospects for hands-on and inquiry-based science learning where standard resources are limited or unavailable. This study investigated the knowledge upper-primary teachers have of science instructional-material improvisation and the challenges they perceived in using improvised resources in the Okaikwei North Municipality of Ghana. The study was underpinned by the pedagogical design capacity and ecological interpretation of teacher agency and employed a quantitative cross-sectional census survey. All 81 eligible public-school teachers participated. Data were collected with a 15-item multiple-choice knowledge test and an 11-item challenge questionnaire; the challenge scale had a Cronbach's alpha of .84. Frequencies and percentages were used for analysis. The findings revealed uneven teacher knowledge: 40.7% were classified in the moderate band, 32.1% in the high band, and 27.2% in the low band. The most frequently endorsed constraints were lack of motivation (93.8%), inadequate support from school authorities (91.4%), insufficient preparation time (90.1%), and perceived negative learner attitudes (84.0%). By contrast, most teachers rejected lack of awareness of the value of improvisation as a major explanation for low use. The findings suggest that resourcefulness depends not only on individual knowledge but also on the organizational conditions that enable teachers to mobilize local materials. Practical professional learning, collaborative design routines, secured preparation time, and stronger instructional leadership are recommended. Because the study used self-reported constraints and a locally developed knowledge test, the findings should be interpreted as context-specific baseline evidence rather than causal estimates of classroom practice.

Keywords: improvised instructional materials; pedagogical design capacity; teacher agency; primary science; resource-constrained schools.

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Introduction

Contemporary science education expects learners to investigate phenomena, interpret evidence, develop explanations, and apply scientific ideas to unfamiliar and everyday situations. At the primary level, these practices depend heavily on opportunities to interact with objects, representations, and phenomena rather than encounter science mainly through verbal exposition. A recent scoping review of primary science interventions similarly shows that the quality of learning opportunities is shaped by the tasks, resources, and forms of teacher support available to learners (Deehan et al., 2024). Yet practical and inquiry-oriented science remains difficult to enact in many resource-constrained systems. Across African competence-based curriculum reforms, persistent limitations in teacher preparation, funding, class size, instructional resources, and assessment support continue to sustain teacher-centred practices despite learner-centred policy intentions (Wawire et al., 2026).

This policy-practice burden is apparent in Ghana. The Standards-Based Curriculum for Basic 4–6 supports activity-based learning and inspires teachers to include the use of teaching and learning resources from their immediate environment to assist investigations (National Council for Curriculum and Assessment [NaCCA], 2019). Nonetheless, present indications from Ghana identify the absence of laboratories, equipment, consumables, and instructional support as persistent problems to practical STEM teaching (Akon-Yamga et al., 2024). Broader studies of curriculum reform also caution that ambitious reforms are undermined when teachers receive inadequate preparation and implementation support (Buabeng & Amo-Darko, 2025). The use of locally available materials for a purposive approach to creating resources through selection, modification, or construction (i.e., "improvising") of commercially manufactured resource(s) can be especially useful in settings where access to standard laboratory equipment is limited (Akuma & Callaghan, 2016; Anor et al., 2026).

These improvised resources are typically made up of materials such as plastic bottles, cardboard boxes, wire, clay, wood, plants, and household items, which are modified to represent a model, an experimental device, or a tool for scientific inquiry. While the primary advantage of using improvised resources is the ability to replace commercially manufactured products, they also provide an opportunity to relate students' existing knowledge about their everyday lives to the learning objectives of the classroom. In addition, locally created resources offer a method by which teachers may better explain practical experiments. Initiatives utilizing locally accessible materials in Ghana have shown that it is possible to create culturally appropriate and hands-on STEM-related experiences while meeting the requirements of the national curriculum (Issifu et al., 2025; Hanson & Beem, 2024). Additionally, there is evidence from schools with severely limited access to resources that if the design and implementation of improvisational strategies are successful, students will become more engaged and participate more actively in hands on experimentation which can improve their science performance (Dhurumraj & Moola, 2023). Improvisation does not mean just using whatever or presenting anything that has been discarded. In order for teachers to utilize resources in an educational way, they need to identify what aspects of the science can be learned from the particular resource, understand how learners will interact with the resource, and ensure that all interactions are safe, accurate, and appropriate.

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These demands make improvisation a procedure of pedagogical design rather than a simple reaction to shortage. Brown's (2009) concept of pedagogical design capacity portrays teachers' ability to recognize and assemble available resources to craft instruction. Current extensions of this perception highlight that design capacity is also collaborative: colleagues, shared routines, and professional dialogue can develop resources through which teachers resolve instructional limitations (Ellingson & Roehrig, 2025). An ecological account of teacher agency adds that professional action is attained through the interaction of teachers' knowledge and goals with cultural, structural, and material circumstances (Priestley et al., 2015). Together, these perspectives indicate that knowledge of improvisation is vital but may be insufficient when teachers lack time, leadership support, collegial collaboration, or professional recognition.

Recent studies support this difference between awareness and enactment. Ghanaian pre-teachers' knowledge and attitudes towards improvisation have been linked with their acquaintance to laboratory resources and practical experiences (Anane & Ankamah Lomotey, 2023). Primary teachers in the Zabzugu District reported familiarity with improvisation but also acknowledged continuing needs for practical training, resources, and policy support (Inusah et al., 2025). A qualitative Ghanaian study published in 2026 relatedly found that teachers used locally available materials to respond to standards-based curriculum demands, while inadequate training, limited time, and weak institutional support inhibited systematic usage (Anor et al., 2026). These studies imply that the significant issue is not only whether materials exist locally, but whether teachers have the knowledge and supporting conditions to translate them into instructionally meaningful resources.

The current literature nonetheless leaves two significant gaps. First, much of the empirical work concerns secondary science, teacher trainees, or broad curriculum implementation, whereas upper-primary teachers work at a level where concrete experiences are particularly critical for developing scientific understanding. Second, studies frequently examine either teachers' acquaintance with improvisation or general implementation barriers, providing fewer evidence on how knowledge and perceived constraints coexist within the same teacher population. Context-specific proof is especially scarce for the Okaikwei North Municipality.

The present study addressed these gaps by investigating upper-primary science teachers' knowledge of improvised instructional materials and the constraints they encounter in using them. The study if specifically guided by the following research questions:

1. What is the level of upper-primary science teachers' knowledge of instructional-material improvisation?
2. What constraints do upper-primary science teachers encounter in preparing and using improvised instructional materials for science teaching?

Theoretical Underpinning

The study was underpinned by pedagogical design capacity and ecological teacher agency. Pedagogical design capacity views teaching as design work in which teachers perceive the affordances of available resources, make instructional decisions, and assemble or convert those resources to achieve learning goals (Brown, 2009). In improvisation, significant personal resources

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incorporate science content knowledge, pedagogical knowledge, practical construction skills, safety awareness, and beliefs about the acceptability of locally produced materials. Material resources include the substances obtainable in schools and communities, while curricular resources comprise learning standards, lesson expectations, and assessment demands.

While this perspective emphasizes an individual's ability to create solutions based on his or her own knowledge; there are also collaborative design abilities that view peers, shared practices, and professional conversations as a resource in finding answers to design problems (Ellingson & Roehrig, 2025). Additionally, the ecological approach to teacher agency explains why knowledge isn't automatically converted into practice: it takes place through collaboration and interaction among teachers' competences and motivations, the opportunities and restrictions of the school environment, and the broader policy framework (Priestley et al., 2015). The framework therefore focused attention on both the knowledge teachers conveyed to improvisation and the organizational conditions that facilitated or constrained its enactment. It also disallowed a deficit interpretation in which inadequate use is ascribed only to individual teachers.

Methodology

Research Design and Setting

The study was underpinned by the positivist research paradigm, which emphasises objective measurement and the systematic analysis of observable phenomena (Cohen et al., 2018). Consistent with this paradigm, a quantitative research approach was employed to generate numerical data on teachers' knowledge and perceived constraints. Specifically, a cross-sectional survey design was adopted to examine the distribution of these variables at a single point in time. The design was not intended to establish causal relationships or directly observe teachers' classroom practices. The study was conducted in the Okaikwei North Municipality in Ghana's Greater Accra Region. Public basic schools in the municipality implement the national Standards-Based Curriculum but vary in their access to science equipment, instructional materials, storage facilities, and school-level support.

Population and Participants

The population of the study comprised all teachers responsible for teaching science at the basic-school level. The target population consisted of all teachers who taught science in Grades 4 to 6 in public basic schools within the Okaikwei North Municipality. The accessible population comprised the 81 qualified Grades 4–6 science teachers identified through records obtained from the Municipal Education Directorate at the time of data collection. Because this accessible population was relatively small and manageable, the study employed a census approach by inviting all 81 teachers to participate. All 81 teachers provided usable responses; therefore, the achieved sample was identical to the accessible population. Although this complete coverage supported an accurate description of the defined municipal population, the findings cannot be statistically generalised to science teachers outside the Okaikwei North Municipality.

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Instrumentation

Two instruments developed by the researcher were used. The first was a 15-item multiple-choice knowledge test covering the content and pedagogical content knowledge on improvisation. Correct responses attracted one point and incorrect responses zero, yielding scores from 0 to 15. For descriptive reporting, scores were divided into equal-width bands: low (0–5), moderate (6–10), and high (11–15). These bands were used as descriptive categories and should not be translated as externally validated mastery standards.

The second instrument was a challenge questionnaire comprising 11 items focusing on knowledge and skills, preparation time, financial constraints, class size, storage, motivation, learner perceptions, perceived appropriateness of improvised materials, and school-authority support. Items were rated from 1 (strongly disagree) to 5 (strongly agree). For transparency, strongly agree and agree were merged as agreement; disagree and strongly disagree were merged as disagreement; undecided responses were retained separately.

Validity and reliability issues

Three specialists in science education and educational research reviewed the instruments for clarity, relevance, content coverage, and alignment with the research questions. The instruments were subsequently piloted with 15 upper primary teachers in the Ablekuma Central Municipality, one of the neighboring municipalities, and minor wording and sequencing changes were made. The challenge scale produced a Cronbach's alpha of .84, indicating adequate internal consistency for group-level description (Taber, 2018). Internal-consistency coefficients and item-difficulty/discrimination statistics were not available for the knowledge test; this limitation is acknowledged in interpreting the knowledge classifications.

Data Collection and Ethics

Ethical Approval (SGS-EC-006-25) was obtained from the Institutional Ethical Review Board of the University of Education, Winneba. Permission was obtained from Okaikwei North Municipality and all participating school heads. Teachers were informed about the study's purpose, voluntary participation, confidentiality, and right to withdraw, and informed consent was obtained before administration. Instruments were completed by individual participants during scheduled school visits and were collected immediately after completion. No names were recorded; identification codes were used, and findings were reported in aggregate.

Data Analysis

Responses were checked, coded, and analysed in IBM SPSS Statistics, Version 28. Frequencies and percentages were used to describe knowledge bands and questionnaire responses. Because the study questions were descriptive and the study did not account for a validated continuous challenge construct, inferential comparisons and claims of prediction were not made. The analysis distinguishes between perceived constraints and actual barriers to learning; it also does not assert that the reported factors caused certain classroom practices.

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Results and Discussion

This section presents and discusses the findings of the study according to the two research questions. Descriptive statistics, including frequencies and percentages, are used to report teachers' knowledge of instructional-material improvisation and their perceived constraints. The findings are interpreted in relation to the study's theoretical framework and relevant literature.

Research Question 1: What is the level of upper-primary science teachers' knowledge of instructional-material improvisation?

To address Research Question One, teachers' knowledge of instructional-material improvisation was assessed using a 15-item knowledge test. Each correct response attracted one point, producing possible scores ranging from 0 to 15. The scores were classified into three descriptive knowledge levels: low (0–5), moderate (6–10), and high (11–15). Frequencies and percentages were subsequently calculated to determine the distribution of the 81 teachers across these knowledge levels. Results on teachers' knowledge scores are presented in Table 1.

Table 1: *Distribution of teachers' knowledge scores*

Score range	Frequency	Percentage	Knowledge level
0–5	22	27.2	Low
6–10	33	40.7	Moderate
11–15	26	32.1	High
Total	81	100.0	

Source: Field Data- Questionnaire (2025)

Teachers' scores were distributed across all three knowledge bands (Table 1). Thirty-three teachers (40.7%) were in the moderate band, 26 (32.1%) in the high band, and 22 (27.2%) in the low band. Thus, 72.8% achieved at least the moderate band, but only approximately one-third reached the high band. The result is better interpreted as uneven knowledge than as evidence that the teaching population was generally proficient, particularly because the bands are descriptive rather than externally validated standards.

The distribution supports the argument that acknowledging the importance of local materials is different from owning the design knowledge needed to use them safely and conceptually. Recent Ghanaian studies similarly report teacher eagerness and familiarity alongside continuing requirements for practical preparation and material-design support (Inusah et al., 2025). Anane and Ankamah Lomotey (2023) also indicate that practical experience is appropriate for pre-teachers' knowledge and attitudes towards improvisation. Considered through pedagogical design capacity, the high-band teachers may be more able to observe the instructional affordances of familiar objects, whereas teachers in the moderate and low bands may need support in concept representation, construction, testing, safety, and the orchestration of learner activity.

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The finding has a professional-learning implication. The 26 teachers in the high band exemplify a possible local resource, but their knowledge should not be presumed to transfer automatically to colleagues. Structured co-design sessions, lesson study, demonstration lessons, and shared material repositories could turn individual expertise into collaborative design capacity. Ellingson and Roehrig (2025) report that social interaction can become a resource for curriculum design; this indicates that school-based collaboration may be more sustainable than isolated workshops focused only on awareness.

Research Question 2: What constraints do upper-primary science teachers encounter in preparing and using improvised instructional materials for science teaching?

To address Research Question Two, teachers' perceptions of the constraints they encountered in preparing and using improvised instructional materials were examined using questionnaire items. Responses were grouped into agree, undecided and disagree categories and analysed using frequencies and percentages. The constraint items were then arranged according to the proportion of teachers who agreed with each statement to identify the most widely perceived challenges. The results are presented in Table 2.

Table 2: *Perceived constraints on the use of improvised instructional materials*

Constraint	Agree, n (%)	Undecided, n (%)	Disagree, n (%)
Lack of motivation	76 (93.8)	2 (2.5)	3 (3.7)
Inadequate support from school authorities	74 (91.4)	1 (1.2)	6 (7.4)
Insufficient preparation time	73 (90.1)	0 (0.0)	8 (9.9)
Perceived negative learner attitudes	68 (84.0)	4 (4.9)	9 (11.1)
Financial constraints	53 (65.4)	13 (16.0)	15 (18.5)
Insufficient improvisation skills	50 (61.7)	20 (24.7)	11 (13.6)
Insufficient knowledge of improvisation	49 (60.5)	17 (21.0)	15 (18.5)
Perceived inappropriateness of improvised resources	49 (60.5)	21 (25.9)	11 (13.6)
Large class sizes	49 (60.5)	13 (16.0)	19 (23.5)
Inadequate storage facilities	22 (27.1)	7 (8.6)	52 (64.2)
Lack of awareness of the importance of improvisation	10 (12.3)	7 (8.6)	64 (79.0)

Source: Field Data- Questionnaire (2025)

In addition, other teacher-identified constraints include economic issues (65.4%), an inability to develop skills for improvising lesson plans (61.7%), insufficient teacher knowledge, doubts about whether the material is appropriate, and a high number of students per classroom (60.5% each). However, relatively few teachers identified limited space for storing materials as limiting their ability to create improvised instructional materials (27.1%). Furthermore, very few teachers stated a lack of knowledge about the value of improvised materials as limiting their use of such materials (12.3%).

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These results reveal a knowledge-practice disconnect. While most of the teachers indicated that they understood the importance of improvisation, however most said they lacked the time, support, motivation, or ability to put their knowledge into practice. The apparent contradiction in this relationship can be explained from an ecological perspective of agency. Professional accomplishment depends on the combination of one's individual capacity and other environmental variables such as available culture and structure (Priestley et al., 2015). Additionally, these results align with the literature indicating that curriculum implementation practices based upon student-centred instructional strategies are hampered by inadequate professional development, lack of adequate financial resource availability, lack of sufficient resources, and high-class sizes (Wawire et al., 2026).

Preparation time is a particularly significant constraint because improvisation requires obtaining, cleaning, adapting, testing, integrating, and regularly maintaining resources. Current Ghanaian studies identify time constraints and institutional support as persistent limitations on systematic improvisation (Anor et al., 2026; Inusah et al., 2025). The 91.4% support for inadequate school-authority support highlights the school's responsibility as an instructional design environment. Leadership can provide secure planning time, modest funds, storage, recognition, and opportunities for collaboration; without these conditions, improvisation becomes an individual and often unrewarded responsibility.

It is possible to infer that the motivation item produced the largest amount of validation. However, one must exercise caution in this inference due to the prevalence of lack of motivation among teachers, which can encompass factors such as recognition, work load, cost of materials, efficiency, and the climate provided by school administrators. For example, research has demonstrated that teachers' performance and motivation are related to their working conditions and support from the organization in Ghana (Forson et al., 2021). Future research should attempt to isolate specific motivational sources, instead of treating motivation as a singular factor.

Teachers' accounts of negative learner perceptions also require cautiousness. The study collected teachers' perceptions, not learner data, and therefore cannot determine that learners essentially rejected improvised resources. Some teachers might anticipate that locally made materials will be regarded as substandard to orthodox equipment, especially when construction quality or instructional purpose is vague. Learner involvement in collecting, constructing, testing, and refining resources may help reposition improvisation as a scientific enterprise rather than a deficient substitute. This suggestion should be verified with direct learner evidence.

The low endorsement of inadequate storage is prominent because storage is regularly presumed to be a noteworthy material barrier. In this municipality, immediate organisational conditions—time, leadership support, and motivation—were perceived as more persistent. The pattern affirms a shift from a slight scarcity narrative to a design-ecology interpretation. Locally available resources do not switch into instructional resources until teachers acquire the knowledge, time, collaboration, and institutional legitimacy to assemble them.

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Interpretation of findings

Taken holistically, the findings yielded two contributions. Analytically, they offer classified evidence from an under-researched upper-primary setting and differentiate knowledge of improvisation from the conditions for enactment. Conceptually, they reveal the practicality of connecting pedagogical design capacity with ecological teacher agency. The knowledge distribution denotes teachers' personal design resources; the challenge responses represent features of the environment that may allow or constrain those resources. The study therefore reframes improvisation from an individual action of creativity to a situated form of professional design work.

The findings also have significance beyond Ghana. Competence- and inquiry-oriented modifications often assume that teachers can translate ambitious curriculum goals into locally workable lessons. In resource-constrained situations, that translation comprises more than supplying policy documents or encouraging creativity. It demands systems that foster design knowledge and require time, collaboration, materials, and leadership support. This broader implication offers the municipal case international relevance while preventing claims that the occurrence estimates denote other settings.

Implications for Research and Practice

For practice, professional development ought to pay attention to the whole design cycle: appreciating the learning goal, selecting materials, examining conceptual accuracy and safety, creating and testing the resource, planning learner interaction, and judging whether the material reinforced explanation and inquiry. Training that uses locally available materials has improved Ghanaian teachers' confidence to conduct hands-on STEM activities (Hanson & Beem, 2024), but persistent school-based routines are desirable to move from workshop confidence to regular enactment. Municipal and school leaders should institute collaborative design periods, peer mentoring, shared inventories of tested materials, and modest budgets for consumables. High-knowledge teachers can facilitate co-designing, but leadership should prevent shifting responsibility solely onto individual "creative" teachers.

For policy, supervision should attend to supporting conditions rather than considering the availability of improvised resources. School supervision could examine whether teachers have planning time, access to professional support, safe storage where needed, and opportunities to test resources. Teacher education programmes should make improvisation an assessed component of science methods courses, including the diagnosis of misleading models and unsafe designs.

For research, the next step is to examine enactment directly. Classroom observations, artefact analysis, interviews, and learner data are needed to determine how knowledge scores relate to the quality and frequency of improvised-material use. Intervention studies could test whether collaborative design routines improve teachers' knowledge, the quality of materials, and learner outcomes. Measurement research is similarly anticipated to corroborate a multidimensional improvisation-knowledge instrument and differentiate technical knowledge, pedagogical integration, safety, and contextual adaptation.

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Limitations

The study has five main limitations. First, it was conducted in one municipality and used a census of a bounded population; the percentages should not be generalised statistically to Ghana as a whole. Second, the constraints were self-reported and may reflect social desirability, interpretation of item wording, or perceived rather than observed conditions. Third, learner attitudes were reported by teachers and were not independently measured. Fourth, the knowledge bands were equal-width descriptive categories rather than validated proficiency thresholds. Fifth, although the challenge scale showed adequate internal consistency, item-level psychometric evidence was provided for the knowledge test. These limitations mean that the study offers useful baseline and hypothesis-generating evidence but cannot establish causality or the quality of classroom enactment.

Conclusion

Upper-primary science teachers in the Okaikwei North Municipality exhibited irregular knowledge of instructional-material improvisation: most were in the moderate or high descriptive bands, but only about one-third reached the high band. Teachers also perceived strong organisational and professional constraints, predominantly limited motivation, weak school-authority support, insufficient preparation time, and negative learner attitudes. The pattern unveils that knowledge of improvisation is not the major drawback. The major drawback is transforming knowledge and local objects into harmless, conceptually precise, and inquiry-supporting instruction within supportive school environments. Consolidating practical design knowledge is consequently essential, but it should be harmonized by collaborative planning, instructional leadership, protected time, and professional recognition. Potential research should authenticate the procedures and examine actual classroom practice and learner outcomes.

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