

Suitability Of Chemistry Laboratory Equipment in Secondary Schools: Evidence from Bungoma Central Sub-County, Kenya

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Abstract- *Chemistry occupies a strategic place in Kenya's science curriculum, yet KCSE performance in the subject has remained poor for over a decade. Drawing on the first objective of a larger descriptive survey, this paper examines the suitability of Chemistry laboratory equipment in public secondary schools in Bungoma Central Sub-County, Western Kenya. The study was guided by Dewey's experiential learning theory and adopted a descriptive survey design. A sample of 320 respondents was drawn from a universe of 2,210, comprising principals, Heads of Chemistry Department, Chemistry teachers, laboratory technicians, Form Four students, the Sub-County Quality Assurance and Standards Officer, and the SMASSE Sub-County coordinator. Data were generated through questionnaires, interview schedules, and an observation checklist, and analysed with descriptive statistics using SPSS version 19.0. Findings showed that Chemistry laboratory equipment was inadequate in 53.2% of the schools and that 33.8% of available resources were locally improvised, against 26.8% from government supply. When equipment was lacking, 46.5% of respondents reverted to theoretical instruction. The principal barriers to equipment acquisition were unreliable Constituency Development Fund disbursements (70.4%), inadequate government allocations (64.8%), and teacher understaffing (35.2%). The study concludes that equipment inadequacy is a systemic barrier to effective Chemistry instruction and recommends timely government funding, transparent CDF allocation, and the deployment of professionally qualified teachers and laboratory technicians.*

Keywords: *Chemistry laboratory equipment; Laboratory Research Method; Improvisation; Secondary schools.*

I. INTRODUCTION

Chemistry remains one of the lowest-performing science subjects in the Kenya Certificate of Secondary Education (KCSE) examination, with sub-county schools registering an average mean grade of

about C- across biology, physics and chemistry combined (KNEC, 2023). The under-performance is consequential because Chemistry is the gatekeeper subject for science-based university programmes such as pharmacy, medicine and engineering, disciplines that anchor Kenya's Vision 2030 and the broader Sustainable Development Goals (Adewusi, 2020). Khamali, Mondoh and Kwen (2025) note that competence in Chemistry depends on a delicate combination of conceptual, manipulative and observational skills, all three of which are cultivated in the laboratory.

The laboratory is therefore the central instructional site for school Chemistry. Gongden, Gongden and Lohdip (2020) report that learners taught and assessed in well-equipped laboratories visualise abstract chemical phenomena more accurately and retain content longer than peers who learn the same content theoretically. This claim has a clear theoretical anchor in Dewey's experiential learning, in which knowledge is constructed through purposeful interaction between the learner and the material environment (Reid & Ali, 2020). It is on this foundation that the Laboratory Research Method (LRM) is built. LRM denotes the systematic use of supervised, learner-led practical investigations to drive concept formation in Chemistry. Inquiry-based and hands-on laboratory approaches operationalising LRM have repeatedly been shown to foster higher-order thinking, scientific literacy and positive attitudes towards science (Reid & Ali, 2020; Ndiokubwayo, Uwamahoro, & Ndayambaje, 2018). The pedagogical promise of LRM, however, depends on the availability and suitability of laboratory equipment. In Kenya, Khamali, Mondoh and Kwen (2025) found a significant positive relationship

between the availability of laboratory materials and Chemistry performance in Kilifi North Constituency, while underscoring that resource inadequacy persists in many public secondary schools. Comparable shortfalls have been documented across sub-Saharan Africa: Kyado, Achor and Adejoh (2021) reported that a sizeable proportion of Lagos post-primary schools lacked functional laboratories, with measurable consequences for Chemistry performance, and similar patterns are evident in Ghana (Asare, Parker, & Osei-Himah, 2018), Rwanda (Ndihokubwayo et al., 2018) and South Africa (Ramaila, 2022). The cumulative picture is one in which the formal Chemistry curriculum across the region is being implemented under conditions of chronic equipment scarcity.

Yet, despite this regional evidence and the strategic importance of Chemistry to Kenya's development agenda, no recent peer-reviewed study has examined the suitability of Chemistry laboratory equipment in Bungoma Central Sub-County since the post-2008 surge in secondary-school enrolment driven by the Free Day Secondary Education policy. The present paper, drawn from a larger study on the integration of LRM in the teaching of Chemistry, addresses this gap. It establishes the adequacy of laboratory equipment in the sub-county, identifies the principal sources from which schools obtain it, and characterises the obstacles to its acquisition, with a view to informing policy and instructional practice.

II. STATEMENT OF THE PROBLEM

KCSE Chemistry has long been a problem subject in Bungoma Central Sub-County. Between 2008 and 2010, the average school mean for the schools that subsequently took part in this study fell from 3.46 to 3.41 (a Grade D plain), more than eight grade points below the expected mean of 12.00 (Grade A plain). That baseline performance motivated the present fieldwork. The trend has not reversed: in the 2023 KCSE, Chemistry was singled out by KNEC for remedial attention nationally, and most rural sub-county schools in Bungoma County continued to register Chemistry mean grades below C+, with only a handful of county schools reaching B-plain (KNEC, 2023). The persistence of poor performance, against the backdrop of substantial public investment through

Free Day Secondary Education, the Constituency Development Fund, and the SMASSE programme, indicates a structural rather than transitory problem.

The current problem is that Chemistry laboratory equipment in many secondary schools in Bungoma Central Sub-County is inadequate in quantity, of uneven quality, and erratic in supply. Sub-County education officials had observed that most laboratories depended heavily on improvised materials and on irregular donor supplies, and that statutorily mandated government allocations were arriving late or in substandard condition. These observations, gathered during preliminary consultations with the Sub-County Quality Assurance and Standards Officer, prompted the systematic investigation reported here.

The consequences are layered. First, equipment inadequacy forces teachers to fall back on theoretical instruction, denying learners the hands-on experience on which constructivist Chemistry pedagogy depends (Ndihokubwayo et al., 2018; Khamali et al., 2025). Second, learners' attitudes towards Chemistry deteriorate as the subject is increasingly perceived as abstract and examination-driven rather than investigative and practical (Musengimana, Kampire, & Ntawiha, 2021; Reid & Ali, 2020). Third, persistent under-performance in KCSE Chemistry reduces the proportion of students qualifying for science-based tertiary programmes through the Kenya Universities and Colleges Central Placement Service, thereby constricting the national pipeline of scientists and science teachers (KNEC, 2023; Adewusi, 2020). Fourth, the shortfall entrenches inequality: well-resourced national and county schools continue to record B and B+ mean grades, while resource-constrained sub-county schools cluster around C and below (KNEC, 2023; Ramaila, 2022).

These consequences acquire fresh urgency under Kenya's transition to the Competency-Based Curriculum and the new KCSE grading framework introduced for the 2023 cohort, both of which place a higher premium on practical and competency-based assessment than the legacy 8-4-4 system did. Schools that cannot offer adequate laboratory experiences in Chemistry now risk a structural disadvantage, not only in examinations but in the competence claims

that the new curriculum is designed to certify. It is on this basis that the present paper interrogates the suitability of Chemistry laboratory equipment in Bungoma Central Sub-County, beginning with a review of the relevant literature.

III. LITERATURE REVIEW

3.1 Role of Laboratory Equipment in Chemistry Pedagogy

A Chemistry laboratory is more than a physical space; it is a multisensory environment that supports discovery, inquiry and the construction of scientific knowledge through learners' own manipulations (Reid & Ali, 2020). Gongden, Gongden and Lohdip (2020) argue that when pupils perform experiments themselves, they integrate visual, tactile and cognitive inputs and are better able to conceptualise the macroscopic, submicroscopic and symbolic representations that constitute the so-called Chemistry triplet (Ngendabanga, Nkurunziza, & Mugabo, 2025a). This integrative process operationalises the Laboratory Research Method, in which the laboratory is not an adjunct to the lesson but the principal site of concept formation. The literature, however, is largely silent on the minimum equipment threshold below which this integrative process breaks down, a gap that has direct policy relevance for resource-constrained schools.

3.2 Adequacy and Quality of Laboratory Equipment

Recent studies converge on a shortfall in laboratory equipment across sub-Saharan Africa, although they differ in design and operational definitions of adequacy. In Nigeria, Kyado, Achor and Adejoh (2021) used a descriptive checklist on a sample of senior secondary schools in Lagos State and reported that about 5% of schools lacked a Chemistry laboratory entirely while a larger proportion operated under-stocked facilities. In Rwanda, Ngendabanga, Nkurunziza and Mugabo (2025b) used a qualitative phenomenological design with eight experienced chemistry teachers in two districts and found that theoretical teaching dominated owing to material shortages, with improvised chemicals such as ash, lemon and eggshells used to bridge the gap between theory and practice.

In the Kenyan context, Khamali, Mondoh and Kwen (2025) used a correlational design in Kilifi North Constituency to demonstrate a statistically significant relationship between the availability of laboratory materials and Chemistry performance, while explicitly noting that material inadequacy persists despite policy commitments. Their use of self-reported availability data is a methodological limitation that future studies should address through direct observation. Earlier Kenyan thesis-level evidence from Meru South and Lugari sub-counties similarly reported under-stocked laboratories and an over-reliance on demonstration teaching even where laboratories were available. Cumulatively, the body of work suggests that adequacy is a necessary but not sufficient condition for effective Chemistry teaching, and that adequacy itself is unevenly defined across studies.

3.3 Sources of Laboratory Equipment and the Role of Improvisation

Chemistry laboratories in Kenyan public secondary schools are stocked through four channels: government procurement administered by the Kenya Institute of Curriculum Development and the Kenya Secondary Schools Equipment Project; Constituency Development Fund (CDF) allocations; donor contributions; and teacher-driven improvisation. Okori and Jerry (2017) define improvisation as the act of producing teaching and learning resources from locally available alternative materials when standard equipment is inaccessible. Several authors view improvisation as both a coping strategy and a constructivist resource: because improvised apparatus is drawn from learners' everyday environments, it can arouse curiosity and connect classroom Chemistry to lived experience (Githui, Koech, & Thinguri, 2021; Asare, Parker, & Osei-Himah, 2018; Ibe, Obikezie, & Chikendu, 2021; Ramaila, 2022). Ibe et al. (2021) provide quasi-experimental evidence that learners taught with improvised materials achieve higher retention than those taught without them.

Nonetheless, improvisation has well-documented limits. Ramothwala and Ramaila (2020) and Asare et al. (2018) show that the pedagogical value of improvised resources depends on teacher creativity, content mastery and access to technical training, none of which can be assumed in under-resourced schools.

Where improvised materials are used only for demonstration or fail to replicate the precision of standard apparatus, learners may form misconceptions about instrumentation and measurement. The Kenyan SMASSE programme, launched jointly with the Japan International Cooperation Agency in 1998, formalised improvisation through the Activity, Student, Experiment, Improvisation (ASEI) and Plan, Do, See, Improve (PDSI) framework. Earlier evaluations of SMASSE in Kenyan secondary schools, however, found only modest impact on KCSE Mathematics and Chemistry outcomes, partly because of cascade-model design weaknesses, low teacher buy-in, and a continuing scarcity of instructional equipment that improvisation alone cannot offset; Iyamuremye, Twagilimana and Niyonzima (2024) develop a similar argument for Rwandan secondary schools, pointing to limited engagement and participation as a parallel constraint. The evidence therefore points to improvisation as a complement to, not a substitute for, sustained equipment supply.

3.4 Challenges in the Acquisition of Laboratory Equipment

Empirical work across Africa identifies a common set of obstacles to the acquisition of Chemistry laboratory equipment. These include inadequate government budget lines, unreliable and sometimes opaque CDF disbursements, donor unreliability and the supply of expired or sub-standard chemicals, teacher understaffing in science subjects, and insufficient technical training for teachers and laboratory technicians (Kyado et al., 2021; Ramaila, 2022; Ndiokubwayo, Uwamahoro, & Ndayambaje, 2018). Khamali et al. (2025) add that, even where central allocations exist, the timing of disbursements rarely aligns with the school calendar, leaving teachers to improvise during the most examination-relevant terms.

Despite this growing body of evidence, no recent peer-reviewed study has examined the suitability of Chemistry laboratory equipment in Bungoma Central Sub-County, a sub-county whose secondary-school enrolment expanded sharply after the 2008 Free Day Secondary Education policy. The literature does not yet specify the source mix, the quality profile, or the principal acquisition obstacles for Chemistry

laboratory equipment in this context, nor does it report how teachers cope when equipment is unavailable. The present paper addresses these gaps.

3.5 Theoretical Framework

This study is anchored in Dewey's experiential learning theory and its constructivist extensions in the work of Piaget and Vygotsky (Reid & Ali, 2020). Dewey held that genuine learning emerges through purposeful interaction between the learner and the material environment; constructivism extends this to argue that learners build understanding by acting on the world rather than by receiving it. In Chemistry, this means that conceptual mastery requires sustained, supervised practical work in which learners manipulate apparatus, observe reactions and reason about outcomes. The Laboratory Research Method operationalises these commitments in school Chemistry. From this framework follow three propositions tested in the present study: (i) effective LRM presupposes adequate and suitable equipment; (ii) where equipment is inadequate, teachers will substitute improvisation, theoretical instruction or peer-school sharing; and (iii) the choice among substitutes will be shaped by the obstacles teachers face in equipment acquisition. The Results section examines each proposition in turn.

IV. RESEARCH METHODOLOGY

4.1 Research Design

The study adopted a descriptive cross-sectional survey design. The choice of design followed directly from the constructivist-experiential framework set out in Section 3.5: because the framework holds that effective Chemistry learning requires sustained interaction between learners and adequate laboratory equipment, the empirical task was to characterise the conditions under which this interaction is or is not currently possible. A descriptive survey is well suited to that task because it permits the systematic measurement of resource conditions across a dispersed sample of schools using structured instruments, without manipulating the variables of interest. The design therefore aimed to describe and interrogate, rather than test causal claims about, the suitability of Chemistry laboratory equipment in the study area. The principal research question was: how suitable is Chemistry laboratory equipment for the

effective implementation of the Chemistry curriculum in public secondary schools in Bungoma Central Sub-County?

4.2 Location of the Study

The research was conducted in Bungoma Central Sub-County, Western Kenya. The sub-county is part of Bungoma County and lies in a predominantly agricultural region, with sugarcane, maize and dairy farming as the main economic activities. At the time of the fieldwork, the sub-county hosted 27 public secondary schools comprising three county boys', three county girls' and two county mixed schools, alongside three sub-county boys', five sub-county girls' and eleven sub-county mixed schools. Combined enrolment exceeded 12,310 learners, of whom approximately 2,100 were Form Four candidates. The mix of school categories made the sub-county appropriate for studying equipment suitability across resource strata.

4.3 Target Population and Sample

The target population comprised 27 principals, 27 Heads of Chemistry Department (HoDs), 27 Chemistry teachers, 27 laboratory technicians, 2,100 Form Four students, 1 Sub-County Quality Assurance and Standards Officer (SCQASO) and 1 SMASSE Sub-County coordinator, giving a universe of 2,210 respondents. A drawn sample of 320 respondents (14.5% of the universe) was selected using a combination of purposive sampling for the institutional respondents and simple random sampling for the 210 Form Four students. The 14.5% proportion follows Kerlinger's (1986) recommendation that a sample of 10–30% of a defined target population is acceptable in descriptive studies. Stratified sampling was used to ensure that the county and sub-county school strata, and the boys', girls' and mixed school categories within each stratum, were proportionally represented. Realised participation was approximately 90% across categories, with attrition concentrated among Form Four students.

Table 1. Sampling Techniques and Drawn Sample Size

Category of Respondents	Universe (N)	Sample (n)	Sampling Technique
Principals	27	27	Purposive
Heads of Chemistry Department	27	27	Purposive
Chemistry Teachers	27	27	Purposive
Laboratory Technicians	27	27	Purposive
Form Four Students	2,100	210	Simple Random
SCQASO	1	1	Purposive
SMASSE Sub-County Coordinator	1	1	Purposive
Total	2,210	320	14.5%

4.4 Instruments and Procedures

Four instruments were used to generate data. Two structured questionnaires combined closed-ended Likert items with open-ended prompts: the Teacher and Laboratory Technician Questionnaire (TLQ) and the Students' Questionnaire (SQ) for Form Four respondents. Three interview schedules were prepared for principals, HoDs, the SCQASO and the SMASSE coordinator. An observation checklist was used by the researcher to assess Chemistry laboratory equipment in each sampled school. Suitability was operationalised along four dimensions: (i) quantity, the number of items relative to the school's enrolment; (ii) quality, the working condition of items including expiry status of chemicals; (iii) match to the KICD-recommended apparatus list and KCSE practical paper requirements; and (iv) accessibility, whether items were available for routine practical work or kept in storage.

Instruments were piloted in two schools that were not part of the main sample. The pilot prompted minor revisions to the wording of three items in the TLQ and the addition of a question on chemical expiry status to the observation checklist. Content and face validity were established through expert review by two specialists in Chemistry education and curriculum studies, and construct validity through

pilot testing. Reliability was estimated using a split-half procedure on the questionnaires, yielding a coefficient of 0.83, above the 0.80 threshold recommended by Mugenda and Mugenda (2003) for instruments of this nature. The observation checklist was completed by a single researcher, which is acknowledged as a methodological limitation; future replications would benefit from inter-rater verification.

4.5 Data Analysis

Quantitative responses from the questionnaires and observation checklist were coded and analysed using SPSS, with the original analyses run on version 19.0 and the descriptive computations subsequently re-verified for this paper. Descriptive statistics, namely frequencies and percentages, were generated for each item; no inferential tests were conducted because the study was designed to characterise rather than to test hypotheses about resource conditions. Qualitative responses from the interview schedules and the open-ended questionnaire items were analysed thematically: transcripts were coded inductively for recurrent themes, which were then organised under the four dimensions of suitability defined in §4.4. Triangulation was conducted item-by-item across the four data sources (TLQ, SQ, interviews, observation), with convergent findings reported in §5 and divergent findings flagged where they occurred. Missing data were addressed through pairwise deletion.

Two further data sources informed the contextual framing in §1 and §2 of this paper but were not part of the original fieldwork: the 2022 KCSE Examination Essential Statistics published by the Kenya National Examinations Council (KNEC, 2023) and county-level KCSE rankings for Bungoma County in 2023. These secondary sources were used solely to update the picture of Chemistry performance and were not analysed alongside the primary data.

Ethical clearance was obtained from the relevant university authorities and the National Commission for Science, Technology and Innovation. Participation was voluntary, anonymous, and based on informed consent, and all data were stored securely on password-protected files.

V. RESULTS AND DISCUSSIONS

The findings reported in this section are drawn from primary fieldwork conducted in 2014 in Bungoma Central Sub-County. The discussion situates the findings in conversation with subsequent literature published between 2017 and 2026. The empirical patterns documented here, as Section 5.5 will argue, retain contemporary policy relevance because the structural conditions of equipment supply have not been substantially reformed in the intervening years (Khamali et al., 2025; Ngendabanga et al., 2025b).

Of the 320 respondents drawn into the sample, 288 returned usable responses, giving an effective response rate of 90%. Among respondents, 57.3% were male and 42.7% female. Findings on the suitability of Chemistry laboratory equipment are organised around the four operational dimensions defined in §4.4: quantity, quality, match to KICD-recommended apparatus and KCSE practical paper requirements, and accessibility. The first three dimensions are reported below; observation data on accessibility, which were collected but did not yield item-level frequency counts comparable to the questionnaire data, are summarised at the end of §5.1.

5.1 Adequacy of Chemistry Laboratory Equipment

Respondents were asked whether the Chemistry laboratory equipment and facilities in their schools were adequate for effective implementation of the Chemistry curriculum. The results are presented in Table 2.

Table 2. Adequacy of Chemistry Laboratory Equipment (n = 94 curriculum implementers)

Response	Frequency	Percentage (%)
Adequate	42	44.7
Not adequate	50	53.2
Not sure	2	2.1
Total	94	100.0

As Table 2 shows, 53.2% of curriculum implementers reported that the equipment and facilities in their laboratories were inadequate for effective implementation of the Chemistry curriculum. Only 44.7% rated them as adequate. Direct observation by the researcher further revealed that, even in schools that rated their equipment as

adequate, an estimated 39.7% of the resources available were either of poor quality, expired or mislabelled. The inadequacy was most pronounced in sub-county schools, where enrolment had surged following the introduction of government-subsidised secondary education in 2008 without a commensurate increase in laboratory capacity. These findings are consistent with the resource-shortfall patterns reported by Kyado et al. (2021) for Lagos State and by Khamali et al. (2025) for Kilifi North.

Two further suitability dimensions were addressed through the observation checklist. With respect to the match to KICD-recommended apparatus and KCSE practical paper requirements, observed laboratories typically held the most basic items (test tubes, beakers, retort stands, basic indicators) but were missing items needed for routine examination-relevant practicals such as fume chambers, working gas taps, and burettes in sufficient numbers for whole-class titration work. With respect to accessibility, several schools kept the limited stock of working apparatus in locked storerooms outside the laboratory, retrieving it only for examination preparation. Both observations point to a pattern in which what little adequate equipment exists is not routinely available to learners during the teaching cycle, compounding the headline shortfall reported in Table 2.

5.2 Sources of Chemistry Laboratory Equipment

Respondents were asked to identify the principal sources from which their Chemistry laboratory equipment was obtained. The results are displayed in Table 3.

Table 3. Sources of Chemistry Laboratory Equipment (n = 71 respondents reporting on equipment sources)

Source	Frequency	Percentage (%)
Government	19	26.8
Constituency Development Fund (CDF)	17	23.9
Donors	9	12.7
Improvisation	24	33.8
Parents	2	2.8

Total	71	100.0
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The findings in Table 3 show that improvisation (33.8%) was the largest single source of Chemistry laboratory equipment, followed by government supply (26.8%), CDF (23.9%), donors (12.7%) and parents (2.8%). The 33.8% improvisation share is notably higher than the 15–25% range reported in earlier Kenyan studies and exceeds the levels Khamali et al. (2025) document for Kilifi North; this divergence is one of the paper's novel empirical contributions. That schools relied on improvisation more than on statutory government supply is pedagogically significant. Okori and Jerry (2017), Githui et al. (2021), Asare et al. (2018) and Ibe et al. (2021) have all demonstrated that improvisation, when anchored on sound content and pedagogical knowledge, can support conceptual understanding and even enhance performance. However, the scale of reliance observed here is unlikely to be entirely intentional; it reflects a default response to resource scarcity rather than a deliberate constructivist choice. The SCQASO confirmed in interviews that the Ministry's statutory allocations were unreliable, and that principals had been encouraged to seek alternative sources from CDF, donors, parents and improvisation. This pattern mirrors observations by Ramaila (2022) in South African township schools and by Ndiokubwayo et al. (2018) in Rwanda.

5.3 Coping Mechanisms when Equipment is Inadequate

Having established the scale of inadequacy, respondents were asked how they dealt with equipment shortfalls. Table 4 summarises their responses.

Table 4. Coping Mechanisms for Inadequate Laboratory Equipment (n = 71 respondents)

Strategy	Frequency	Percentage (%)
Improvisation	17	23.9
Sharing with neighbouring schools	21	29.6
Teaching theoretically	33	46.5
Total	71	100.0

Most strikingly, 46.5% of respondents reported that they resorted to purely theoretical instruction when laboratory resources were inadequate, while only 23.9% attempted improvisation and 29.6% explored inter-school resource sharing. This is the paper's second generative finding: under conditions of acute equipment scarcity, the constructivist Laboratory Research Method effectively collapses into transmissive teaching for nearly half of the surveyed implementers. The pattern contradicts the experiential logic that underpins effective Chemistry pedagogy (Reid & Ali, 2020; Ndiokubwayo et al., 2018). When learners are taught the laws of chemical reactivity, stoichiometry and electrochemistry without ever handling a burette, a retort stand or a voltaic cell, the cognitive-manipulative integration described by Gongden et al. (2020) is foreclosed. The SCQASO and the SMASSE coordinator both noted in interviews that theoretical teaching was widely viewed as a last resort to be used only where unavoidable, yet the data show it had become a routine substitute rather than an exception.

5.4 Challenges in the Acquisition of Chemistry Laboratory Equipment

The study further probed the specific obstacles encountered by schools in acquiring Chemistry laboratory equipment. Table 5 reports the findings, classified by source of supply.

Table 5. Challenges in the Acquisition of Chemistry Laboratory Equipment (n = 71)

Source	Challenge	Freq.	%
Government	Inadequate allocation to science equipment	46	64.8
CDF	Unreliable disbursement	50	70.4
CDF	Too little when received	30	42.3
CDF	Perceived corruption in allocation	35	49.3
Donors	Unreliable supply	20	28.2
Donors	Low quality or expired chemicals	18	25.4
Improvisation	Difficult to improvise chemicals	29	40.8
Improvisation	Lack of interest arousal	55	77.5

	(not real objects)		
Staffing	Understaffing / lack of qualified teachers	25	35.2
Staffing	Poor training for teachers in requisition	38	53.5

Source: Field data, 2014. Note: respondents could cite more than one challenge; column percentages therefore do not sum to 100, and each row reports the percentage of n = 71 citing that obstacle.

Table 5 documents systemic challenges that span supply, quality, and human capacity. The largest single obstacle cited was the perception that improvised materials do not adequately arouse student interest because they are not the real scientific apparatus (77.5%), confirming Ramothwala and Ramaila's (2020) observation that the pedagogical value of improvisation is contingent on how skilfully it is deployed. Unreliable CDF disbursement (70.4%) and inadequate government budget lines for science equipment (64.8%) emerged as the most cited supply-side problems, in line with the patterns described by Khamali et al. (2025) and Kyado et al. (2021). The dumping of expired or low-quality chemicals by some donors (25.4%) raises both pedagogical and occupational-safety concerns, while teacher understaffing (35.2%) and weak training in requisition (53.5%) indicate that even when equipment is available, human-resource gaps can frustrate its effective use.

The interview data triangulate and extend these questionnaire findings. The SCQASO described the timing of central allocations as the deepest structural problem: deliveries arrived late in the school year, after the practical-intensive teaching cycles in Forms Three and Four had already passed, leaving teachers to improvise during the most examination-relevant terms. The SMASSE Sub-County coordinator added that improvisation training reached only a fraction of teachers and that even those trained could not improvise core chemicals (acids, indicators, reactive metals) without compromising safety. Both informants identified the cascade design of the SMASSE in-service model as a contributing factor, an observation that Iyamuremye et al. (2024) develop in a parallel argument about limited teacher engagement with innovative pedagogies in resource-

constrained Rwandan classrooms. Equipment suitability is therefore not a matter of hardware alone but of an ecosystem that links hardware, policy and professional capacity.

5.5 Pedagogical and Policy Implications

Three implications follow from the findings. First, where the constructivist Laboratory Research Method collapses into theoretical teaching for nearly half of the implementers, claims that Kenyan secondary Chemistry is taught in the spirit of the experiential framework cannot be sustained without a parallel investment in equipment supply. Second, because improvisation has come to function as the dominant single source rather than a complement to standard supply, professional development must reframe improvisation as a skilled pedagogical practice and equip teachers and laboratory technicians accordingly. Third, the timing of central disbursements is as consequential as their magnitude: schools that receive equipment after the practical-teaching cycle has passed cannot use it as the curriculum intends. Together, these implications motivate the conclusions and recommendations that follow.

VI. CONCLUSIONS

Set against the principal research question of how suitable Chemistry laboratory equipment is for the effective implementation of the Chemistry curriculum in Bungoma Central Sub-County, the study draws four conclusions. First, Chemistry laboratory equipment is inadequate in most schools, and a substantial proportion of the resources that are available are of poor or doubtful quality. Second, improvisation by teachers, rather than statutory government supply, constitutes the single largest source of Chemistry laboratory materials, at a level that exceeds what earlier Kenyan studies report and signals a default response to scarcity rather than a deliberate constructivist choice. Third, when faced with inadequate equipment, a sizeable share of respondents resort to purely theoretical instruction, indicating that the constructivist Laboratory Research Method has effectively collapsed into transmissive teaching for a substantial share of implementers. Fourth, the main barriers to equipment acquisition are unreliable CDF disbursements, inadequate

government budget allocations, donor unreliability, the difficulty of improvising chemicals, and understaffing combined with weak teacher training in requisition and technical practice. Taken together, these conclusions show that equipment suitability in the study area is a systemic rather than a localised problem, and that addressing it will require coordinated policy, institutional and professional-development interventions.

VII. RECOMMENDATIONS

Based on the conclusions of the study, the following recommendations are made:

1. The Ministry of Education should increase budget allocations for Chemistry laboratory equipment and align disbursements with the academic year, so that schools receive adequate equipment of acceptable quality before the practical-intensive teaching cycles in Forms Three and Four; schools should in turn store working apparatus inside the laboratory and make it available to learners throughout the teaching cycle, rather than reserving it in locked storerooms for examination preparation.
2. Constituency Development Fund committees and donor organisations should coordinate their support with the Ministry of Education by adopting rule-based allocation criteria, publishing annual allocations, and using a quality-control checklist overseen by the Sub-County Quality Assurance and Standards Officer at the point of delivery, so that improvisation by teachers complements rather than substitutes for sustained statutory equipment supply.
3. Schools should restore Chemistry practical work to the routine teaching cycle rather than concentrating practical sessions in the term immediately preceding the KCSE practical paper; Heads of Chemistry Department should record the frequency of practical sessions and submit termly returns to the principal, and the Kenya Institute of Curriculum Development should issue revised guidance on the minimum acceptable frequency of laboratory sessions per topic.
4. The Teachers Service Commission should prioritise the deployment of professionally qualified Chemistry teachers and laboratory technicians to

under-staffed sub-county schools, and the Kenya Institute of Curriculum Development, in collaboration with the SMASSE programme and universities, should institutionalise biannual in-service training for these teachers and technicians, with modules on improvisation, ICT-supported laboratory work, and occupational safety.

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