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## **Waste to Learning: Transforming Waste Materials into Instructional Resources for Effective Teaching in Primary Schools**

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### **Abstract**

*This study examined the transformation of waste materials into instructional resources for effective teaching and learning in English and Mathematics in primary schools in Gumel community, Gumel Local Government Area (GLGA), Jigawa State, Nigeria. Specifically, it identified readily available waste materials, assessed their suitability for instructional use, explored methods of converting them into teaching aids, examined challenges affecting their utilization, and evaluated the effectiveness of teacher training. A pre-test and post-test design involving 40 primary school teachers, comprising 20 English and 20 Mathematics teachers was employed. Data were collected using structured questionnaires and analysed using frequencies, percentages, means, and standard deviations. Before the intervention, used papers (82.5%), plastic bottles (75.0%), and bottle caps (75.0%) were the most readily available waste materials. English teachers generally reported greater availability of waste materials, whereas Mathematics teachers perceived most materials as more suitable for instructional use, particularly bottle caps ( $M = 3.30$ ) and cardboard boxes ( $M = 3.15$ ). Lack of knowledge in transforming waste materials into teaching aids constituted the major challenge for both English ( $M = 4.30$ ) and Mathematics teachers ( $M = 3.70$ ), alongside inadequate institutional support. Following the training, substantial improvements were observed across both subject groups. English teachers rated plastic bottles as highly suitable instructional resources ( $M = 4.80$ ) and reported marked improvements in modifying waste materials into visual aids ( $M = 4.75$ ) and positive classroom practices ( $M = 4.80$ ). Mathematics teachers demonstrated strong gains in assembling waste materials into teaching models ( $M = 4.70$ ) and practical skills in creating teaching aids ( $M = 4.85$ ). At the pooled level, practical skills improved from a pre-training expectation of  $M = 3.15$  to a post-training rating of  $M = 4.78$ , while knowledge-related challenges declined substantially from  $M = 4.00$  to  $M = 1.60$ . Although time constraints remained a concern ( $M = 4.43$ ), teachers reported significantly greater confidence in independently designing and utilizing waste-based instructional resources. The study concludes that teacher training significantly enhances the*

*effective integration of waste materials into English and Mathematics instruction and that teacher preparedness and institutional support are more critical than the mere availability of recyclable materials. The study recommends sustained professional development, stronger school-level support mechanisms, and the integration of waste-to-learning approaches into teacher education programmes to promote innovative, low-cost, and environmentally sustainable teaching practices in primary schools.*

**Keywords:** Waste materials; instructional resources; teaching; primary schools

## **Introduction:**

The quality of teaching and learning in primary education depends substantially on the availability and effective utilization of instructional resources that promote active learner engagement and facilitate conceptual understanding. Constructivist learning theory emphasizes that learners develop meaningful knowledge through active interaction with instructional materials and participation in practical learning experiences rather than passive reception of information (Dong et al., 2021; Mir et al., 2025). Instructional materials therefore serve as essential tools for helping teachers simplify abstract concepts, encourage classroom participation, stimulate learners' interest, and improve knowledge retention. Empirical evidence further demonstrates that the effective use of instructional resources enhances instructional quality and contributes to improved learning outcomes across subject areas (Ndomondo, 2024).

Despite their educational importance, inadequate instructional materials remain a persistent challenge in many primary schools, particularly in low- and middle-income countries where financial constraints and limited educational resources restrict access to commercially produced teaching aids. These limitations reduce teachers' ability to implement learner-centred instructional approaches that require demonstrations, manipulation of objects and active learner participation (Melaku et al., 2025). The challenge is especially pronounced in English and Mathematics, where pupils benefit from concrete instructional materials that support language development, literacy, numeracy and problem-solving skills.

Instructional improvisation has long been recognized as an effective strategy for addressing shortages of conventional teaching materials. By utilizing locally available resources, teachers can develop instructional aids that are affordable, contextually relevant and responsive to learners' needs. Improvisation not only expands access to teaching resources but also encourages creativity, innovation and contextualized learning experiences. However, the effectiveness of instructional improvisation depends on teachers' ability to identify appropriate materials, determine their instructional suitability and transform them into functional teaching resources.

Among the locally available resources with considerable educational potential are waste materials generated within schools and surrounding communities. Plastic bottles, bottle caps, cardboard boxes, paper products, tin containers and fabric scraps are widely available but are frequently discarded without consideration of their instructional value. Repurposing such materials supports the principles of Education for Sustainable Development by promoting responsible resource utilization while simultaneously addressing shortages of classroom resources (UNESCO, 2020). García-Fortes et al. (2025) further demonstrated that integrating waste education into teacher preparation enhances teachers' awareness of sustainable

practices and strengthens their capacity to develop innovative teaching resources. Similarly, İzgiOnbaşılı and ErcanYalman (2025) reported that sustainability-oriented educational practices promote environmental responsibility while encouraging creative use of locally available resources in teaching and learning.

Although waste materials are commonly available in many school environments, their educational value depends largely on teachers' knowledge of how such materials can be used for instructional purposes. Teachers must be able to distinguish materials that are suitable for different learning activities, understand how they can support subject-specific instruction, and apply appropriate techniques for converting them into effective teaching aids. Without adequate knowledge and practical skills, readily available waste materials may remain unused despite their potential to improve classroom instruction.

Evidence also suggests that the availability of instructional resources alone does not guarantee their classroom utilization. Teachers' use of innovative instructional materials is influenced by factors such as confidence, practical competence, institutional support, time, and opportunities for professional learning (Negrín-Medina et al., 2022; Theodorio, 2024). Consequently, many teachers continue to rely on conventional teaching approaches even when recyclable materials that could support active learning are readily accessible. Understanding teachers' current utilization of waste materials and the barriers that limit their use is therefore essential for developing practical interventions that strengthen classroom practice.

Professional development provides an important mechanism for improving teachers' instructional competence and encouraging the adoption of innovative teaching strategies. Practice-oriented training enables teachers to acquire the knowledge and technical skills required to identify, transform and effectively utilize locally available materials in classroom instruction. Liu et al. (2026) concluded that collaborative and practice-based professional learning strengthens teachers' instructional creativity and promotes sustained improvements in classroom practice. However, evidence on the effectiveness of hands-on training specifically designed to improve teachers' capacity to transform waste materials into instructional resources remains limited, particularly in resource-constrained primary school settings.

Existing studies have examined the availability and utilization of instructional resources (Ndomondo, 2024), teachers' implementation of active learning strategies (Melaku et al., 2025), waste education in teacher preparation (García-Fortes et al., 2025), and teacher professional learning (Liu et al., 2026). Nevertheless, these studies have largely addressed these issues independently. Few studies have simultaneously examined the waste materials available within school communities, teachers' knowledge of their instructional use, current levels of classroom utilization, the challenges affecting their application, and the effectiveness of practical training in strengthening teachers' ability to transform waste materials into instructional resources for teaching English and Mathematics. Furthermore, empirical evidence addressing these issues within Nigerian primary schools remains limited.

Addressing these evidence gaps is important because improving teachers' capacity to utilize locally available waste materials offers an affordable and sustainable strategy for strengthening classroom instruction while promoting environmental stewardship. Generating evidence on the availability, suitability and instructional utilization of waste materials, as well as on the effectiveness of practical teacher training, can inform policies and professional

development programmes aimed at enhancing teaching quality in resource-constrained schools.

This study therefore examined and supported primary school teachers in transforming waste materials into instructional resources for effective teaching and learning in English and Mathematics. Specifically, the study identified waste materials readily available within schools and surrounding communities, assessed teachers' knowledge of the instructional use of waste materials, examined their current utilization in classroom teaching, identified challenges affecting their use, and evaluated the effectiveness of a hands-on training programme designed to strengthen teachers' capacity to transform waste materials into functional instructional resources.

### **Problem Statement/Justification:**

The availability and effective utilization of instructional materials are essential for promoting learner-centred teaching and improving learning outcomes in primary education. However, many public primary schools in Nigeria continue to experience inadequate access to conventional instructional resources because of financial constraints, limited procurement of teaching aids, and competing educational priorities. These limitations reduce teachers' ability to implement practical, activity-based instruction, particularly in English and Mathematics, where pupils require concrete learning experiences to develop literacy, numeracy, and problem-solving skills (Dong et al., 2021; Ndomondo, 2024; Melaku et al., 2025).

At the same time, schools and surrounding communities generate considerable quantities of recyclable waste materials, including plastic bottles, bottle caps, cardboard boxes, paper products, fabric scraps, and other discarded items that could serve as affordable instructional resources. The reuse of these materials not only offers a practical solution to shortages of teaching aids but also supports the principles of Education for Sustainable Development by promoting responsible resource utilization and environmental stewardship (UNESCO, 2020; García-Fortes et al., 2025). Despite their availability, waste materials remain underutilized for instructional purposes in many primary schools, suggesting that the challenge extends beyond resource availability to teachers' knowledge, confidence, and capacity to integrate such materials into classroom practice.

Existing research has examined aspects of instructional resources, active learning, sustainability education, and teacher professional development, but important gaps remain. Ndomondo (2024) investigated the availability and utilization of instructional resources in secondary school history teaching without considering the instructional use of waste materials. Melaku et al. (2025) explored teachers' practices and challenges in implementing active learning strategies but did not examine teachers' knowledge or utilization of waste-based instructional resources. García-Fortes et al. (2025) focused on waste education within teacher preparation programmes and its influence on environmental awareness, rather than on teachers' practical ability to identify, transform, and utilize waste materials for teaching specific school subjects. Likewise, Liu et al. (2026) demonstrated the importance of practice-oriented professional learning for improving instructional practice but did not evaluate training programmes centred on developing waste-based instructional resources. Collectively, these studies provide valuable insights into instructional innovation and teacher development; however, they do not examine the interconnected issues of waste material availability, teachers' knowledge, classroom utilization, barriers to utilization, and the effectiveness of hands-on training within a single intervention.

This evidence gap is particularly evident in the Nigerian primary education context, where empirical studies evaluating structured training programmes on the educational use of waste materials remain scarce. Consequently, there is limited evidence regarding the types of waste materials readily available within school communities, teachers' knowledge of their instructional potential, the extent to which such materials are currently utilized in teaching English and Mathematics, the challenges constraining their use, and whether practical training can enhance teachers' capacity to transform waste materials into effective instructional resources. The absence of such evidence limits the ability of educators, school administrators, and policymakers to design cost-effective and sustainable strategies for strengthening classroom instruction while promoting responsible environmental practices.

This study was undertaken to address these gaps by examining the availability of waste materials within schools and surrounding communities, assessing teachers' knowledge and current utilization of waste materials for instructional purposes, identifying the challenges affecting their use, and evaluating the effectiveness of a structured hands-on training programme in strengthening teachers' capacity to transform waste materials into instructional resources for teaching English and Mathematics. The findings provide empirical evidence to support sustainable, low-cost instructional practices that can enhance teaching effectiveness while encouraging environmentally responsible resource utilization in primary schools.

### **General objective**

To examine and support primary school teachers in transforming waste materials into instructional resources for effective teaching and learning in English and Mathematics.

### **Specific objectives**

The specific objectives of the study are to:

1. To identify waste materials readily available in schools and surrounding communities.
2. To determine the types of waste materials suitable for instructional use in teaching English and Mathematics in primary schools.
3. To explore practical methods for converting waste materials into instructional teaching aids.
4. To examine challenges faced by teachers in using waste materials for instructional purposes.
5. To train and support primary school teachers in the hands-on transformation of waste materials into classroom instructional resources.

## **2. Research Questions**

The following research questions will guide the study:

1. What types of waste materials are readily available in schools and surrounding communities?
2. What knowledge do primary school English and Mathematics teachers have regarding the use of waste materials for instruction?

3. To what extent do teachers currently use waste materials in teaching English and Mathematics?
4. What challenges limit teachers' use of waste materials as instructional resources?
5. How effective is training in improving teachers' ability to transform waste materials into instructional resources?

## **Literature Review:**

### **Waste materials as instructional resources**

Instructional materials are fundamental to effective teaching and learning because they promote learner engagement, enhance conceptual understanding, and facilitate active participation. This perspective is consistent with constructivist learning theory, which posits that learners actively construct knowledge through interaction with their environment, learning materials, and social experiences (Piaget, 1952; Schunk, 2020; Vygotsky, 1978; Woolfolk, 2022). Contemporary educational research continues to support this view, emphasizing that learners develop deeper understanding through interaction with concrete materials and authentic learning experiences rather than passive reception of information (Dong et al., 2021; Mir et al., 2025; Mengistie & Belay, 2026).

This perspective shows the importance of instructional resources in primary education, particularly in English and Mathematics, where pupils benefit from manipulative and activity-based learning experiences. However, inadequate access to conventional instructional materials continues to constrain learner-centred instruction in many resource-limited schools (Ndomondo, 2024; Melaku et al., 2025).

Transforming waste materials into instructional resources has emerged as a practical and sustainable strategy for addressing these shortages. Recyclable materials such as plastic bottles, bottle caps, cardboard boxes, paper products and fabric scraps can be repurposed into teaching aids while promoting environmental sustainability and reducing material costs. This approach aligns with UNESCO's Education for Sustainable Development framework, which advocates responsible resource utilization and environmental stewardship through education (UNESCO, 2020). García-Fortes et al. (2025) demonstrated that waste education within teacher preparation programmes strengthens teachers' sustainability awareness and influences their instructional practices. Likewise, İzgi Onbaşılı and Ercan Yalman (2025) reported that sustainability-oriented educational approaches enhance environmental citizenship by encouraging learners and teachers to utilize locally available materials creatively. Similarly, Xiong et al. (2025), in a systematic review of environmental literacy pedagogies, concluded that experiential and resource-based teaching approaches strengthen learners' environmental awareness and support the integration of sustainability concepts into classroom practice.

### **Availability and suitability of waste materials for classroom instruction**

The instructional potential of waste materials depends largely on their availability within schools and surrounding communities. Many recyclable materials generated through household, commercial and school activities are inexpensive, readily accessible and capable of being adapted into instructional resources. Plastic bottles can serve as counting devices and science models, cardboard can be transformed into alphabet or number cards, while bottle caps, paper products and other recyclable materials can be converted into manipulatives that support literacy and numeracy instruction.

Availability alone, however, does not guarantee instructional effectiveness. Waste materials must also be suitable for specific learning objectives, safe for classroom use, durable and appropriate for pupils' developmental levels. Consequently, effective utilization depends not only on access to materials but also on teachers' ability to identify suitable waste materials and transform them into meaningful instructional resources that align with curriculum requirements.

### **Teachers' knowledge and utilization of waste materials as instructional resources**

Teachers' knowledge and instructional competence are central to the successful use of waste materials in classroom teaching. Beyond recognizing the educational potential of recyclable materials, teachers require practical skills to transform them into functional teaching aids and pedagogical competence to integrate them effectively into lessons. Previous studies indicate that innovative instructional practices are strongly influenced by teachers' professional knowledge, confidence and willingness to adopt learner-centred approaches (Negrín-Medina et al., 2022; Theodorio, 2024).

Although instructional improvisation has long been advocated as a strategy for addressing shortages of educational resources, evidence suggests that classroom utilization remains inconsistent. Ndomondo (2024) found that the availability of instructional resources does not necessarily translate into effective classroom utilization, while Melaku et al. (2025) reported that teachers continue to encounter challenges in implementing active learning strategies despite recognising their educational value. Collectively, these findings suggest that improving classroom utilization requires strengthening teachers' practical knowledge and instructional capacity rather than merely increasing resource availability.

### **Challenges affecting the utilization of waste materials**

Several institutional and professional factors constrain teachers' use of waste materials as instructional resources. These include inadequate professional training, limited technical skills, insufficient institutional support, lack of time for preparing instructional materials and heavy teaching workloads. Such constraints often discourage teachers from adopting innovative instructional practices even when recyclable materials are readily available. Wang et al. (2025) found that increasing workload reduces teachers' engagement with innovative educational practices, while Theodorio (2024) emphasized that sustained institutional support and continuous professional development are essential for the successful adoption of new instructional approaches. Addressing these barriers therefore requires supportive school environments alongside opportunities for practical capacity building.

### **Teacher professional development and hands-on training in instructional improvisation**

Teacher professional development is widely recognised as an important mechanism for improving instructional quality and promoting educational innovation. Practice-oriented professional learning enables teachers to acquire the technical, pedagogical and creative skills required to develop contextually relevant instructional resources. Liu et al. (2026), in a systematic review, concluded that educational design research provides an effective model for teacher professional learning because it promotes collaborative problem-solving, reflection and practical application. Similarly, Negrín-Medina et al. (2022) demonstrated that continuous professional development enhances teachers' confidence and willingness to adopt innovative instructional practices. These findings suggest that structured hands-on training can strengthen teachers' capacity to identify, transform and utilize waste materials effectively for teaching English and Mathematics.

## **Summary of literature and knowledge gap**

The reviewed literature demonstrates that waste materials represent a sustainable and affordable alternative to conventional instructional resources and have considerable potential for promoting learner-centred teaching while supporting environmental sustainability. Previous studies have examined instructional resource utilization (Ndomondo, 2024), active learning practices (Melaku et al., 2025), sustainability and waste education (García-Fortes et al., 2025; İzgi Onbaşılı & Ercan Yalman, 2025; Xiong et al., 2025), constructivist teaching (Mengistie & Belay, 2026), and teacher professional development (Liu et al., 2026; Negrín-Medina et al., 2022). However, these studies have generally investigated these issues independently. Limited empirical evidence exists on the availability of waste materials within primary school environments, teachers' knowledge and utilization of these materials for teaching English and Mathematics, the challenges affecting their classroom use, and the effectiveness of structured hands-on training in strengthening teachers' capacity to transform waste materials into instructional resources, particularly in the Nigerian context. This study addresses these gaps by evaluating a practical Waste-to-Learning training programme that integrates sustainable resource utilization with teacher professional development to improve instructional practice in resource-constrained primary schools.

## **Methodology:**

The study adopts a pre-test, intervention, and post-test research design. The design is considered appropriate because the study seeks not only to examine primary school teachers' existing knowledge and practices regarding the use of waste materials as instructional resources but also to provide practical training and determine the effectiveness of the intervention in improving teachers' capacity to transform waste materials into teaching aids. The pre-test phase was used to establish teachers' baseline knowledge, skills, and challenges, while the intervention phase involved practical training and hands-on activities on converting waste materials into instructional resources. The post-test phase was conducted after the training to determine changes in teachers' knowledge, confidence, and practical ability.

The study was carried out in Gumel community of Gumel Local Government Area (GLGA), Jigawa State, Nigeria. Gumel is one of the local government areas in Jigawa State and different waste materials are generated within school environments and surrounding communities. The population of the study comprises all English and Mathematics primary school teachers in Gumel community. The population consists of 40 teachers, and since the population is manageable, the entire population will be used for the study using a census approach.

Three instruments were used for data collection, namely questionnaire, oral interview guide, and training guide. The questionnaire was used to obtain information on waste materials available within schools and communities, teachers' knowledge of suitable waste materials for instructional purposes, methods of transforming waste materials into teaching aids, challenges affecting their utilization, and teachers' expected improvement through training. The oral interview guide was used to obtain additional information on teachers' experiences and perceptions regarding the use of waste materials in classroom instruction. The training guide was used during the practical workshop sessions where teachers were guided on how to transform selected waste materials into instructional resources for teaching English and Mathematics.

The instruments were subjected to face and content validation by experts in education, curriculum studies, and measurement and evaluation to ensure that the items are clear,

relevant, and appropriate for the objectives of the study. The reliability of the questionnaire was established using Cronbach's Alpha to determine the internal consistency of the items. The reliability test produced an overall Cronbach's Alpha coefficient of 0.848, indicating that the instrument is reliable and suitable for the study.

Data collection began with the administration of the pre-test questionnaire to teachers. After the pre-test, a practical training workshop was conducted where teachers participated in hands-on activities involving the identification, modification, and use of waste materials for classroom instruction. Following the intervention, a post-test questionnaire was administered to determine the effectiveness of the training. Data collected was analyzed using frequency counts, percentages, mean, and standard deviation to answer the research questions. Cronbach's Alpha will be used to establish the reliability of the instrument, while paired sample t-test will be used to determine whether there is a significant difference between teachers' pre-test and post-test scores after the training intervention.

## **Data Analysis**

### **Results:**

#### **Pre test**

Plastic bottles were available to 90.0% of English teachers compared with 60.0% of Mathematics teachers, resulting in an overall availability rate of 75.0% (see Table 1). This suggests that plastic bottles constitute a readily accessible resource, particularly among English teachers, and could be effectively repurposed for instructional activities such as language games, labeling exercises, counting tasks, and demonstrations.

Cardboard boxes were reported as available by 80.0% of English teachers and 45.0% of Mathematics teachers, with an overall availability of 62.5%. The lower level of accessibility among Mathematics teachers indicates that opportunities for utilizing cardboard materials in constructing teaching aids may vary across subject areas.

Bottle caps were available to 90.0% of English teachers and 60.0% of Mathematics teachers, yielding a pooled availability of 75.0%. Their widespread availability suggests considerable potential for classroom use, particularly in Mathematics for counting, sorting, pattern recognition, and basic arithmetic activities, as well as in English language instruction for letter recognition, word formation, and vocabulary games.

Used papers emerged as the most available waste material across both groups, with availability rates of 95.0% among English teachers and 70.0% among Mathematics teachers, producing an overall rate of 82.5%. This high prevalence highlights their versatility for developing instructional resources such as flashcards, charts, worksheets, story prompts, and problem-solving exercises.

Tin cans were available to 85.0% of English teachers and 50.0% of Mathematics teachers, with a pooled availability of 67.5%. Their moderate accessibility suggests opportunities for creating practical teaching aids, although their utilization may depend on subject-specific instructional needs and safety considerations.

Fabric scraps represented the least available waste material, being reported by 70.0% of English teachers and only 40.0% of Mathematics teachers, resulting in an overall availability of 55.0%. This comparatively lower availability may constrain their use in instructional

activities; nevertheless, where accessible, they could support creative learning tasks, including storytelling, dramatization, geometric shape construction, and other hands-on activities.

English teachers consistently reported higher availability of all categories of waste materials than Mathematics teachers. Despite these differences, the findings indicate that commonly available waste products—particularly used papers, plastic bottles, and bottle caps—provide substantial opportunities for developing low-cost, locally sourced instructional materials capable of enhancing both English language and Mathematics teaching.

**Table 1: Availability of waste materials before training among English teachers (n = 20), Mathematics teachers (n = 20) and the pooled sample (N = 40)**

| Waste material  | Frequency (%) |             |           |
|-----------------|---------------|-------------|-----------|
|                 | English       | Mathematics | Pooled    |
| Plastic bottles | 18 (90.0)     | 12 (60.0)   | 30 (75.0) |
| Cardboard boxes | 16 (80.0)     | 9 (45.0)    | 25 (62.5) |
| Bottle caps     | 18 (90.0)     | 12 (60.0)   | 30 (75.0) |
| Used papers     | 19 (95.0)     | 14 (70.0)   | 33 (82.5) |
| Tin cans        | 17 (85.0)     | 10 (50.0)   | 27 (67.5) |
| Fabric scraps   | 14 (70.0)     | 8 (40.0)    | 22 (55.0) |

Plastic bottles were perceived as highly suitable for instructional purposes by both groups of teachers, although Mathematics teachers reported a higher mean score ( $M = 3.30$ ,  $SD = 0.86$ ) than English teachers ( $M = 2.95$ ,  $SD = 0.69$ ). The pooled mean of 3.13 ( $SD = 0.81$ ) indicates that plastic bottles were generally regarded as the most suitable waste material for classroom instruction prior to the training. Their versatility for demonstrating mathematical concepts, organizing learning activities, and supporting language exercises may explain these positive perceptions.

Cardboard boxes received a mean rating of 2.75 ( $SD = 0.72$ ) among English teachers and 3.15 ( $SD = 0.88$ ) among Mathematics teachers, producing a pooled mean of 2.95 ( $SD = 0.83$ ). This suggests that Mathematics teachers considered cardboard boxes more useful for constructing instructional aids such as geometric models, number boards, and measurement tools, whereas English teachers expressed more moderate views regarding their applicability.

Substantial differences emerged in perceptions of bottle caps. English teachers rated them relatively low in suitability ( $M = 1.55$ ,  $SD = 0.89$ ), while Mathematics teachers reported one of the highest ratings ( $M = 3.30$ ,  $SD = 0.80$ ). The pooled mean of 2.43 ( $SD = 1.21$ ) masks this divergence and indicates considerable variation in perceptions across subject areas. The findings suggest that Mathematics teachers recognized the usefulness of bottle caps for counting, sorting, pattern formation, and arithmetic activities, whereas English teachers perceived fewer opportunities for their instructional application.

Used papers were viewed more favourably by Mathematics teachers ( $M = 2.50$ ,  $SD = 0.69$ ) than by English teachers ( $M = 1.95$ ,  $SD = 1.00$ ), yielding a pooled mean of 2.23 ( $SD = 0.89$ ). Despite their high availability, teachers generally perceived them as only marginally suitable for instruction before the training, indicating limited awareness of their potential for developing worksheets, flashcards, literacy materials, and problem-solving exercises.

Similarly, tin cans received a mean score of 1.75 ( $SD = 0.85$ ) among English teachers and 2.50 ( $SD = 0.76$ ) among Mathematics teachers, with an overall mean of 2.13 ( $SD = 0.88$ ).

The relatively low ratings suggest that teachers had not fully considered their possible use as instructional resources, although Mathematics teachers demonstrated greater appreciation of their utility for practical and manipulative learning activities.

Fabric scraps recorded the lowest acceptance across both groups, with mean scores of 2.05 (SD = 1.02) for English teachers and 2.35 (SD = 0.67) for Mathematics teachers, resulting in a pooled mean of 2.20 (SD = 0.86). These findings indicate that fabric materials were generally viewed as having limited instructional value prior to the intervention (see Table 2).

Mathematics teachers consistently perceived most waste materials as more suitable for instructional use than English teachers, with the exception of plastic bottles, where perceptions were positive among both groups. The pronounced differences in ratings for bottle caps, used papers, and tin cans suggest that teachers' subject specializations influence how they recognize and utilize locally available waste materials. These findings underscore the need for training programmes that broaden teachers' awareness of innovative and subject-specific applications of recycled resources in both Mathematics and English language instruction.

**Table 2: perceived suitability of waste materials for instruction before training among English teachers (n = 20), Mathematics teachers (n = 20) and the Pooled Sample (N = 40)**

| Waste material  | English Mean (SD) | Mathematics Mean (SD) | Pooled Mean (SD) |
|-----------------|-------------------|-----------------------|------------------|
| Plastic bottles | 2.95 (0.69)       | 3.30 (0.86)           | 3.13 (0.81)      |
| Cardboard boxes | 2.75 (0.72)       | 3.15 (0.88)           | 2.95 (0.83)      |
| Bottle caps     | 1.55 (0.89)       | 3.30 (0.80)           | 2.43 (1.21)      |
| Used papers     | 1.95 (1.00)       | 2.50 (0.69)           | 2.23 (0.89)      |
| Tin cans        | 1.75 (0.85)       | 2.50 (0.76)           | 2.13 (0.88)      |
| Fabric scraps   | 2.05 (1.02)       | 2.35 (0.67)           | 2.20 (0.86)      |

Cutting and reshaping waste materials into teaching aids was the most frequently reported transformation method among both groups of teachers, with Mathematics teachers (M = 2.90, SD = 0.97) reporting greater use than English teachers (M = 2.50, SD = 0.69). The pooled mean of 2.70 (SD = 0.86) indicates moderate engagement with this practice prior to the training, suggesting that teachers possessed some practical skills in adapting locally available materials into instructional resources.

The use of labeling and marking techniques recorded mean scores of 2.05 (SD = 0.89) among English teachers and 2.40 (SD = 0.68) among Mathematics teachers, yielding a pooled mean of 2.23 (SD = 0.81). These findings suggest relatively limited application of this method before the intervention. Nevertheless, labeling and marking have considerable instructional potential, particularly for English language activities involving vocabulary development, word recognition, and grammar instruction, as well as for Mathematics tasks requiring symbols, numbers, and classifications.

Teachers also reported occasional use of assembling different waste items to create teaching models, with Mathematics teachers (M = 2.75, SD = 0.91) demonstrating higher utilization than English teachers (M = 2.35, SD = 1.05). The pooled mean of 2.55 (SD = 0.99) suggests moderate familiarity with this approach. The greater use among Mathematics teachers may reflect the suitability of assembled models for teaching geometric concepts, measurement,

and spatial reasoning, while English teachers may have had fewer opportunities to employ such materials in language instruction.

Painting and decorating waste materials received relatively low ratings across both groups, with mean scores of 2.05 (SD = 1.10) for English teachers and 2.35 (SD = 0.67) for Mathematics teachers, resulting in a pooled mean of 2.20 (SD = 0.92). This finding indicates that aesthetic modification of waste materials was not a common instructional practice before the training, despite its potential to increase learner engagement and improve the attractiveness of teaching aids.

Modifying waste materials into visual aids recorded one of the highest mean scores, with English teachers reporting a mean of 2.55 (SD = 1.15) and Mathematics teachers a mean of 2.60 (SD = 0.82). The pooled mean of 2.58 (SD = 0.98) suggests that visual adaptation represented a relatively familiar practice among teachers. In English language classrooms, such visual aids could support reading, storytelling, and vocabulary acquisition, while in Mathematics they may facilitate the teaching of numbers, shapes, and problem-solving concepts.

The involvement of learners in constructing instructional materials received the lowest ratings among all methods, with English teachers reporting a mean of 1.80 (SD = 0.89) and Mathematics teachers reporting a mean of 2.10 (SD = 0.64). The pooled mean of 1.95 (SD = 0.78) indicates minimal learner participation in transforming waste materials into teaching resources prior to the intervention. This finding suggests that instructional practices remained predominantly teacher-centred, limiting opportunities for experiential learning, creativity, collaboration, and learner ownership of the educational process (see Table 3).

Mathematics teachers consistently reported greater use of waste-material transformation methods than English teachers across all six practices. The findings indicate moderate awareness and application of basic adaptation techniques but reveal limited utilization of participatory approaches involving learners. The results underscore the importance of professional development initiatives aimed at strengthening teachers' capacity to creatively transform locally available waste materials into subject-specific instructional resources while promoting active learner engagement in both Mathematics and English language classrooms.

**Table 3: Methods used in transforming waste materials into instructional resources before training among English teachers (n = 20), Mathematics teachers (n = 20) and the Pooled Sample (N = 40)**

| Statement                                                   | English Mean (SD) | Mathematics Mean (SD) | Pooled Mean (SD) |
|-------------------------------------------------------------|-------------------|-----------------------|------------------|
| I cut and reshape waste materials into teaching aids.       | 2.50 (0.69)       | 2.90 (0.97)           | 2.70 (0.86)      |
| I use labeling and marking techniques.                      | 2.05 (0.89)       | 2.40 (0.68)           | 2.23 (0.81)      |
| I assemble different waste items to create teaching models. | 2.35 (1.05)       | 2.75 (0.91)           | 2.55 (0.99)      |
| I paint or decorate waste materials.                        | 2.05 (1.10)       | 2.35 (0.67)           | 2.20 (0.92)      |
| I modify waste materials into visual aids.                  | 2.55 (1.15)       | 2.60 (0.82)           | 2.58 (0.98)      |
| I involve learners in constructing instructional materials. | 1.80 (0.89)       | 2.10 (0.64)           | 1.95 (0.78)      |

Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.

Table 4 presents the challenges in using waste materials for instruction before the training programme among English teachers, Mathematics teachers, and the pooled sample. Among English teachers, lack of time was perceived as a major challenge ( $M = 3.85$ ,  $SD = 0.67$ ), indicating that many teachers found it difficult to devote sufficient time to preparing instructional materials from waste products. Lack of knowledge on converting waste materials into teaching aids emerged as the most serious challenge ( $M = 4.30$ ,  $SD = 0.66$ ), suggesting inadequate skills and experience in utilizing such resources effectively. Inadequate school support was also identified as a substantial barrier ( $M = 4.35$ ,  $SD = 0.59$ ), reflecting concerns about limited institutional encouragement and provision of necessary resources. However, the availability of waste materials was viewed more moderately ( $M = 3.05$ ,  $SD = 0.83$ ), indicating that access to materials was not considered a major obstacle by most respondents.

Among Mathematics teachers, lack of time was rated as a moderate challenge ( $M = 2.70$ ,  $SD = 0.73$ ), implying that time constraints were less problematic compared to their English counterparts. Lack of knowledge remained a notable concern ( $M = 3.70$ ,  $SD = 0.80$ ), though to a lesser extent than among English teachers. School support was also perceived as moderately inadequate ( $M = 3.55$ ,  $SD = 0.76$ ), suggesting some institutional limitations in facilitating the use of waste materials for instruction. The availability of waste materials received a moderate rating ( $M = 3.20$ ,  $SD = 0.77$ ), indicating relatively mixed views regarding access to such resources.

For the pooled sample, lack of time was perceived as a moderate challenge ( $M = 3.28$ ,  $SD = 0.92$ ), indicating that teachers experienced some difficulty balancing instructional preparation with other professional responsibilities. Lack of knowledge emerged as a major barrier ( $M = 4.00$ ,  $SD = 0.79$ ), suggesting that many teachers lacked adequate skills for transforming waste materials into effective teaching aids. Inadequate school support was also identified as a significant challenge ( $M = 3.95$ ,  $SD = 0.80$ ), underscoring the importance of institutional encouragement and resource provision. In contrast, the availability of waste materials was viewed more neutrally ( $M = 3.13$ ,  $SD = 0.79$ ), reflecting mixed opinions among respondents regarding the ease of accessing such materials.

**Table 4: Challenges in using waste materials for instruction before training among English teachers (n = 20), Mathematics teachers (n = 20), and the Pooled sample (N = 40)**

| Statement                                                          | English Mean (SD) | Mathematics Mean (SD) | Pooled Mean (SD) |
|--------------------------------------------------------------------|-------------------|-----------------------|------------------|
| Lack of time prevents me from preparing instructional materials.   | 3.85 (0.67)       | 2.70 (0.73)           | 3.28 (0.92)      |
| I lack knowledge on converting waste materials into teaching aids. | 4.30 (0.66)       | 3.70 (0.80)           | 4.00 (0.79)      |
| My school does not provide adequate support.                       | 4.35 (0.59)       | 3.55 (0.76)           | 3.95 (0.80)      |
| Waste materials are not readily available.                         | 3.05 (0.83)       | 3.20 (0.77)           | 3.13 (0.79)      |

*Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.*

Table 5 presents teachers' expectations regarding the effects of training on instructional practice before participating in the training programme, comparing English teachers, Mathematics teachers, and the pooled sample. Among English teachers, respondents moderately agreed that training would make them more capable of transforming waste

materials into instructional resources ( $M = 3.25$ ,  $SD = 0.72$ ), indicating positive expectations about improving their competence in resource utilization. They also believed that training would enhance their practical skills in creating teaching aids ( $M = 3.10$ ,  $SD = 0.72$ ). Expectations concerning the ability to independently design instructional materials were somewhat lower ( $M = 2.90$ ,  $SD = 0.64$ ), suggesting a degree of uncertainty about achieving complete autonomy in material development. English teachers further expected that training would help them apply waste materials more effectively in teaching ( $M = 3.00$ ,  $SD = 0.79$ ) and would positively influence their classroom teaching practices ( $M = 2.95$ ,  $SD = 0.69$ ).

Among Mathematics teachers, respondents similarly expressed positive expectations regarding the training. They moderately agreed that training would improve their ability to transform waste materials into instructional resources ( $M = 3.20$ ,  $SD = 0.52$ ) and strengthen their practical skills in creating teaching aids ( $M = 3.20$ ,  $SD = 0.52$ ). Mathematics teachers also believed that the training would enable them to independently design instructional materials ( $M = 3.00$ ,  $SD = 0.79$ ) and apply waste materials more effectively in teaching ( $M = 3.05$ ,  $SD = 0.69$ ). The strongest expectation was related to positive changes in classroom teaching practices ( $M = 3.45$ ,  $SD = 0.76$ ), indicating considerable confidence in the potential benefits of the intervention.

For the pooled sample, teachers moderately agreed that the training would enhance their ability to transform waste materials into instructional resources ( $M = 3.23$ ,  $SD = 0.62$ ). They also expected improvements in practical skills for creating teaching aids ( $M = 3.15$ ,  $SD = 0.62$ ). Expectations regarding independent design of instructional materials were relatively modest ( $M = 2.95$ ,  $SD = 0.72$ ). Respondents believed that training would improve the application of waste materials in teaching ( $M = 3.03$ ,  $SD = 0.74$ ). Furthermore, teachers anticipated that the intervention would positively influence their classroom practices ( $M = 3.20$ ,  $SD = 0.79$ ), demonstrating an overall positive attitude toward the training programme.

**Table 5: Expected Effects of Training on Instructional Practice Before Training among English teachers ( $n = 20$ ), Mathematics teachers ( $n = 20$ ), and the Pooled sample ( $N = 40$ )**

| Statement                                                                                        | English Mean (SD) | Mathematics Mean (SD) | Pooled Mean (SD) |
|--------------------------------------------------------------------------------------------------|-------------------|-----------------------|------------------|
| Training will make me more capable of transforming waste materials into instructional resources. | 3.25 (0.72)       | 3.20 (0.52)           | 3.23 (0.62)      |
| Training will improve my practical skills in creating teaching aids.                             | 3.10 (0.72)       | 3.20 (0.52)           | 3.15 (0.62)      |
| Training will enable me to independently design instructional materials.                         | 2.90 (0.64)       | 3.00 (0.79)           | 2.95 (0.72)      |
| Training will help me apply waste materials more effectively in teaching.                        | 3.00 (0.79)       | 3.05 (0.69)           | 3.03 (0.74)      |
| Training will positively change my classroom teaching practices.                                 | 2.95 (0.69)       | 3.45 (0.76)           | 3.20 (0.79)      |

*Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.*

### Post test

Table 6 presents the availability of waste materials after the training programme among English teachers, Mathematics teachers, and the pooled sample. Among English teachers,

plastic bottles, bottle caps, used papers, and tin cans were each available to 95.0% of respondents, indicating widespread access to these materials for instructional purposes. Cardboard boxes and fabric scraps were available to 90.0% of teachers, suggesting that most respondents could readily obtain these resources for classroom activities. Overall, the findings demonstrate a high level of availability of different waste materials among English teachers following the training.

Among Mathematics teachers, bottle caps recorded the highest availability, with all respondents (100.0%) reporting access to them. Plastic bottles and used papers were each available to 95.0% of teachers, while cardboard boxes, tin cans, and fabric scraps were available to 90.0% of respondents. These results indicate that Mathematics teachers also had substantial access to a variety of waste materials that could be transformed into instructional resources.

For the pooled sample, plastic bottles were available to 95.0% of respondents, indicating widespread accessibility for instructional use after training. Cardboard boxes were available to 90.0% of teachers, suggesting substantial potential for reuse in classroom activities. Bottle caps recorded the highest availability (97.5%), making them highly suitable for practical learning tasks. Used papers were available to 95.0% of respondents, reinforcing their usefulness in developing low-cost instructional materials. Tin cans were available to 92.5% of teachers, while fabric scraps were available to 90.0%, indicating improved recognition and utilization of waste resources across both subject groups.

**Table 6: Availability of waste materials after training among English teachers (n = 20), Mathematics teachers (n = 20), and the Pooled sample (N = 40)**

| Waste material  | Frequency (%) |             |           |
|-----------------|---------------|-------------|-----------|
|                 | English       | Mathematics | Pooled    |
| Plastic bottles | 19 (95.0)     | 19 (95.0)   | 38 (95.0) |
| Cardboard boxes | 18 (90.0)     | 18 (90.0)   | 36 (90.0) |
| Bottle caps     | 19 (95.0)     | 20 (100.0)  | 39 (97.5) |
| Used papers     | 19 (95.0)     | 19 (95.0)   | 38 (95.0) |
| Tin cans        | 19 (95.0)     | 18 (90.0)   | 37 (92.5) |
| Fabric scraps   | 18 (90.0)     | 18 (90.0)   | 36 (90.0) |

Table 7 presents teachers' perceptions of the suitability of waste materials for instructional purposes after the training programme among English teachers, Mathematics teachers, and the pooled sample. Among English teachers, plastic bottles recorded the highest mean score ( $M = 4.80$ ,  $SD = 0.41$ ), indicating very strong agreement regarding their suitability as instructional resources. Tin cans ( $M = 4.45$ ,  $SD = 0.60$ ), bottle caps ( $M = 4.40$ ,  $SD = 0.50$ ), and used papers ( $M = 4.40$ ,  $SD = 0.60$ ) were also perceived as highly suitable for teaching and learning activities. Cardboard boxes ( $M = 4.35$ ,  $SD = 0.49$ ) and fabric scraps ( $M = 4.35$ ,  $SD = 0.49$ ) received similarly favourable ratings, suggesting broad acceptance of various waste materials for classroom use.

Among Mathematics teachers, tin cans recorded the highest mean score ( $M = 4.70$ ,  $SD = 0.47$ ), demonstrating strong endorsement of their instructional value. Plastic bottles were also highly rated ( $M = 4.50$ ,  $SD = 0.51$ ), followed closely by cardboard boxes ( $M = 4.55$ ,  $SD = 0.51$ ) and bottle caps ( $M = 4.45$ ,  $SD = 0.51$ ). Used papers ( $M = 4.40$ ,  $SD = 0.50$ ) and fabric scraps ( $M = 4.35$ ,  $SD = 0.75$ ) likewise attracted positive perceptions, indicating that

Mathematics teachers regarded a wide range of waste materials as appropriate for instructional applications after the training.

For the pooled sample, plastic bottles recorded the highest mean score ( $M = 4.65$ ,  $SD = 0.48$ ), indicating strong agreement regarding their suitability for instructional purposes. Tin cans also received substantial endorsement ( $M = 4.58$ ,  $SD = 0.54$ ), while cardboard boxes ( $M = 4.45$ ,  $SD = 0.50$ ) and bottle caps ( $M = 4.43$ ,  $SD = 0.50$ ) were widely accepted as useful teaching resources. Used papers ( $M = 4.40$ ,  $SD = 0.55$ ) were perceived as highly suitable, particularly for creating written and visual materials. Fabric scraps also attracted favourable perceptions ( $M = 4.35$ ,  $SD = 0.62$ ), demonstrating a strong appreciation of their potential instructional value following the training programme.

**Table 7: Perceived Suitability of Waste Materials for Instruction After Training among English teachers ( $n = 20$ ), Mathematics teachers ( $n = 20$ ), and the Pooled sample ( $N = 40$ )**

| Statement       | English Mean (SD) | Mathematics Mean (SD) | Pooled Mean (SD) |
|-----------------|-------------------|-----------------------|------------------|
| Plastic bottles | 4.80 (0.41)       | 4.50 (0.51)           | 4.65 (0.48)      |
| Cardboard boxes | 4.35 (0.49)       | 4.55 (0.51)           | 4.45 (0.50)      |
| Bottle caps     | 4.40 (0.50)       | 4.45 (0.51)           | 4.43 (0.50)      |
| Used papers     | 4.40 (0.60)       | 4.40 (0.50)           | 4.40 (0.55)      |
| Tin cans        | 4.45 (0.60)       | 4.70 (0.47)           | 4.58 (0.54)      |
| Fabric scraps   | 4.35 (0.49)       | 4.35 (0.75)           | 4.35 (0.62)      |

*Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.*

Table 8 presents the methods used in transforming waste materials into instructional resources after the training programme among English teachers, Mathematics teachers, and the pooled sample. Among English teachers, respondents strongly agreed that they cut and reshaped waste materials into teaching aids ( $M = 4.60$ ,  $SD = 0.50$ ), indicating active involvement in developing instructional resources. They also reported frequent use of labeling and marking techniques to convert waste materials into learning tools ( $M = 4.55$ ,  $SD = 0.60$ ). Assembling different waste items to create teaching models received a high rating ( $M = 4.60$ ,  $SD = 0.60$ ), demonstrating creativity and innovation in instructional practice. Teachers further agreed that they painted or decorated waste materials for classroom use ( $M = 4.35$ ,  $SD = 0.49$ ) and modified them into visual aids such as charts, flashcards, and models ( $M = 4.75$ ,  $SD = 0.44$ ), which recorded the highest mean among English teachers. Involving learners in constructing instructional materials from waste items also received a positive rating ( $M = 4.20$ ,  $SD = 0.52$ ), suggesting substantial learner participation in resource development.

Among Mathematics teachers, respondents strongly agreed that they cut and reshaped waste materials into teaching aids ( $M = 4.60$ ,  $SD = 0.50$ ). The use of labeling and marking techniques was also widely practiced ( $M = 4.35$ ,  $SD = 0.59$ ). The highest rating was recorded for assembling different waste items to create teaching models ( $M = 4.70$ ,  $SD = 0.47$ ), indicating extensive use of practical and creative instructional approaches. Mathematics teachers also reported painting or decorating waste materials for classroom use ( $M = 4.40$ ,  $SD = 0.60$ ) and modifying them into visual aids ( $M = 4.45$ ,  $SD = 0.51$ ). However, involving learners in constructing instructional materials obtained a comparatively lower mean score ( $M = 3.55$ ,  $SD = 0.89$ ), suggesting that this practice, although present, was less frequently adopted than other methods.

For the pooled sample, teachers strongly agreed that they cut and reshaped waste materials into teaching aids ( $M = 4.60$ ,  $SD = 0.50$ ), indicating active engagement in resource development after the training. The use of labeling and marking techniques ( $M = 4.45$ ,  $SD = 0.60$ ) became a common instructional practice. Assembling waste items into teaching models achieved one of the highest ratings ( $M = 4.65$ ,  $SD = 0.54$ ), demonstrating enhanced creativity among participants. Painting and decorating waste materials ( $M = 4.38$ ,  $SD = 0.54$ ) was also widely practiced. Modifying waste items into visual aids such as charts, flashcards, or models recorded a high mean score ( $M = 4.60$ ,  $SD = 0.50$ ), reflecting teachers' preference for visual learning materials. Involving learners in constructing instructional resources ( $M = 3.88$ ,  $SD = 0.81$ ) improved considerably, although it remained comparatively lower than other practices.

**Table 8: Methods used in transforming waste materials into instructional resources after training among English teachers ( $n = 20$ ), Mathematics teachers ( $n = 20$ ), and the Pooled sample ( $N = 40$ )**

| Statement                                                                          | English Mean (SD) | Mathematics Mean (SD) | Pooled Mean (SD) |
|------------------------------------------------------------------------------------|-------------------|-----------------------|------------------|
| I cut and reshape waste materials into teaching aids.                              | 4.60 (0.50)       | 4.60 (0.50)           | 4.60 (0.50)      |
| I use labeling and marking techniques to turn waste materials into learning tools. | 4.55 (0.60)       | 4.35 (0.59)           | 4.45 (0.60)      |
| I assemble different waste items to create teaching models.                        | 4.60 (0.60)       | 4.70 (0.47)           | 4.65 (0.54)      |
| I paint or decorate waste materials to make them suitable for classroom use.       | 4.35 (0.49)       | 4.40 (0.60)           | 4.38 (0.54)      |
| I modify waste materials into visual aids such as charts, flashcards, or models.   | 4.75 (0.44)       | 4.45 (0.51)           | 4.60 (0.50)      |
| I involve learners in constructing instructional materials from waste items.       | 4.20 (0.52)       | 3.55 (0.89)           | 3.88 (0.81)      |

*Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.*

Table 9 presents the challenges in using waste materials for instruction after the training programme among English teachers, Mathematics teachers, and the pooled sample. Among English teachers, lack of time remained a significant challenge ( $M = 4.20$ ,  $SD = 0.41$ ), indicating that preparing instructional materials from waste products continued to require considerable effort and commitment. However, respondents strongly disagreed that they lacked knowledge on converting waste materials into teaching aids ( $M = 1.40$ ,  $SD = 0.50$ ), suggesting that the training substantially improved their competencies in this area. English teachers also agreed that their schools did not provide adequate support for the use of waste materials ( $M = 4.40$ ,  $SD = 0.50$ ), highlighting the persistence of institutional constraints. Furthermore, they strongly disagreed that waste materials were not readily available in their environment ( $M = 1.40$ ,  $SD = 0.50$ ), indicating that accessibility was no longer a major concern.

Among Mathematics teachers, lack of time was also perceived as a major challenge and recorded the highest mean score ( $M = 4.65$ ,  $SD = 0.59$ ). In contrast, respondents disagreed that they lacked knowledge on how to convert waste materials into teaching aids ( $M = 1.80$ ,  $SD = 0.52$ ), demonstrating the effectiveness of the training in enhancing practical skills. Mathematics teachers similarly disagreed that their schools failed to provide adequate support ( $M = 1.75$ ,  $SD = 0.55$ ), suggesting a more favourable institutional environment compared to that reported by English teachers. They also disagreed that waste materials were unavailable

in their surroundings ( $M = 1.60$ ,  $SD = 0.50$ ), confirming that access to reusable materials was generally adequate.

For the pooled sample, teachers continued to identify lack of time as a challenge ( $M = 4.43$ ,  $SD = 0.56$ ), suggesting that preparing instructional materials remained demanding despite the training programme. However, respondents strongly disagreed that they lacked knowledge of transforming waste materials into teaching aids ( $M = 1.60$ ,  $SD = 0.53$ ), indicating that the intervention effectively enhanced their competencies. Perceptions regarding institutional support varied considerably between subject groups ( $M = 3.08$ ,  $SD = 1.46$ ), reflecting inconsistent school-level assistance. Teachers generally disagreed that waste materials were unavailable ( $M = 1.50$ ,  $SD = 0.51$ ), implying that access to reusable materials was no longer a major constraint.

**Table 9: Challenges in using waste materials for instruction after training among English teachers ( $n = 20$ ), Mathematics teachers ( $n = 20$ ), and the Pooled sample ( $N = 40$ )**

| Statement                                                              | English Mean (SD) | Mathematics Mean (SD) | Pooled Mean (SD) |
|------------------------------------------------------------------------|-------------------|-----------------------|------------------|
| Lack of time prevents me from preparing instructional materials.       | 4.20 (0.41)       | 4.65 (0.59)           | 4.43 (0.56)      |
| I lack knowledge on how to convert waste materials into teaching aids. | 1.40 (0.50)       | 1.80 (0.52)           | 1.60 (0.53)      |
| My school does not provide adequate support for using waste materials. | 4.40 (0.50)       | 1.75 (0.55)           | 3.08 (1.46)      |
| Waste materials are not readily available in my environment.           | 1.40 (0.50)       | 1.60 (0.50)           | 1.50 (0.51)      |

Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.

Table 10 presents the perceived effects of training on instructional practice after the training programme among English teachers, Mathematics teachers, and the pooled sample. Among English teachers, respondents strongly agreed that the training made them more capable of transforming waste materials into instructional resources ( $M = 4.60$ ,  $SD = 0.50$ ). They also reported substantial improvement in their practical skills in creating teaching aids from waste materials ( $M = 4.70$ ,  $SD = 0.47$ ). The training enabled them to independently design instructional materials using waste resources ( $M = 4.65$ ,  $SD = 0.49$ ) and helped them apply such materials more effectively in classroom instruction ( $M = 4.70$ ,  $SD = 0.47$ ). The highest mean score was recorded for positive changes in classroom teaching practices ( $M = 4.80$ ,  $SD = 0.41$ ), indicating a strong perceived impact of the intervention on instructional delivery.

Among Mathematics teachers, respondents likewise expressed strong agreement regarding the benefits of the training. They indicated that the programme enhanced their ability to transform waste materials into instructional resources ( $M = 4.70$ ,  $SD = 0.47$ ) and significantly improved their practical skills in creating teaching aids ( $M = 4.85$ ,  $SD = 0.37$ ), which recorded the highest mean score within this group. Mathematics teachers also reported increased confidence in independently designing instructional materials ( $M = 4.80$ ,  $SD = 0.41$ ). They agreed that the training improved their application of waste materials in teaching ( $M = 4.60$ ,  $SD = 0.50$ ) and positively influenced their classroom practices ( $M = 4.70$ ,  $SD = 0.47$ ).

For the pooled sample, teachers strongly agreed that the training enhanced their ability to transform waste materials into instructional resources ( $M = 4.65$ ,  $SD = 0.48$ ). Practical skills in creating teaching aids recorded the highest pooled mean ( $M = 4.78$ ,  $SD = 0.42$ ), demonstrating the effectiveness of the intervention. Participants also reported increased confidence in independently designing instructional materials ( $M = 4.73$ ,  $SD = 0.45$ ). The training improved teachers' application of waste materials in English and Mathematics lessons ( $M = 4.65$ ,  $SD = 0.48$ ), while positive changes in classroom practices ( $M = 4.75$ ,  $SD = 0.44$ ) confirmed the overall impact of the programme.

**Table 10: Perceived effects of training on instructional practice after training among English teachers (n = 20), Mathematics teachers (n = 20), and the Pooled sample (N = 40)**

| Statement                                                                                          | English Mean (SD) | Mathematics Mean (SD) | Pooled Mean (SD) |
|----------------------------------------------------------------------------------------------------|-------------------|-----------------------|------------------|
| Training has made me more capable of transforming waste materials into instructional resources.    | 4.60 (0.50)       | 4.70 (0.47)           | 4.65 (0.48)      |
| Training has improved my practical skills in creating teaching aids from waste materials.          | 4.70 (0.47)       | 4.85 (0.37)           | 4.78 (0.42)      |
| Training has enabled me to independently design instructional materials using waste resources.     | 4.65 (0.49)       | 4.80 (0.41)           | 4.73 (0.45)      |
| Training has helped me apply waste materials more effectively in teaching English and Mathematics. | 4.70 (0.47)       | 4.60 (0.50)           | 4.65 (0.48)      |
| Training has positively changed my classroom teaching practices.                                   | 4.80 (0.41)       | 4.70 (0.47)           | 4.75 (0.44)      |

Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.

## Discussion

This study examined the effect of a teacher training intervention on the use of waste materials as instructional resources for teaching English and Mathematics in primary schools. The findings indicate that the intervention substantially improved teachers' recognition of recyclable materials as instructional resources, strengthened their competence in transforming and integrating these materials into classroom instruction, increased learner participation in resource development, and enhanced instructional practices across both subject areas. The intervention also reduced knowledge-related barriers to implementation, although time constraints and variations in institutional support remained important challenges to sustaining these practices.

The findings suggest that the principal barrier to waste-to-learning initiatives before the intervention was not the availability of recyclable materials but teachers' ability to recognize their instructional potential. Most of the commonly used waste materials, including used papers, plastic bottles and bottle caps, were already available in schools before the training. The substantial improvements observed after the intervention therefore appear to reflect a shift in teachers' perceptions rather than increased access to materials. Teachers began to view everyday waste as educational resources capable of supporting classroom instruction. This finding suggests that shortages of instructional resources in many primary schools may result more from underutilization of locally available materials than from their actual

scarcity. Ndomondo (2024) similarly observed that locally available resources frequently remain underused until teachers develop the knowledge and confidence required to incorporate them into classroom practice.

The intervention also demonstrated that teachers' disciplinary backgrounds influenced how waste materials were initially perceived and applied. Before training, English teachers generally reported greater availability of recyclable materials, whereas Mathematics teachers more readily recognized their instructional value, particularly for developing manipulative resources that support counting, measurement, classification and spatial reasoning. Following the intervention, however, teachers in both subject areas reported substantial improvements in their ability to utilize waste materials, although they continued to apply them in ways that reflected the distinct pedagogical demands of their disciplines. Rather than producing uniform instructional practices, the training broadened teachers' capacity to adapt locally available resources to their specific classroom contexts. This suggests that professional development programmes are likely to be more effective when they strengthen general instructional innovation while remaining responsive to the unique pedagogical requirements of different subject areas.

A notable outcome of the intervention was the transformation in teachers' perceptions of the suitability of waste materials for classroom instruction. Materials that previously received relatively low ratings, including used paper, bottle caps and fabric scraps, were widely regarded as appropriate instructional resources after the training. This change indicates that the educational value of recyclable materials is shaped primarily by teachers' professional knowledge rather than by the inherent characteristics of the materials themselves. Practical engagement during the training enabled teachers to reconsider how familiar objects could support learning, consistent with constructivist perspectives that emphasize learning through experience, reflection and active participation. Dong et al. (2021) similarly argue that experiential learning promotes changes in professional knowledge by enabling educators to reconstruct existing understandings through practice.

The findings further demonstrate that the intervention influenced instructional practice beyond simply increasing the use of waste materials. Before training, teachers reported limited competence in converting recyclable materials into instructional resources and relied largely on teacher-prepared teaching aids. Following the intervention, both English and Mathematics teachers demonstrated substantially greater competence in modifying, assembling and adapting waste materials for classroom instruction, while learner involvement in producing instructional resources also increased considerably. These improvements suggest that waste-to-learning initiatives can promote more participatory and learner-centred approaches to teaching rather than functioning solely as low-cost alternatives to commercially produced instructional materials. Mir et al. (2025) similarly noted that learner participation in constructing instructional resources strengthens active learning by encouraging greater engagement, creativity and collaboration.

Another important finding is that the intervention substantially reduced knowledge-related barriers while highlighting the continuing importance of institutional support. Before the training, teachers consistently identified inadequate knowledge and technical skills as major constraints to utilizing waste materials effectively. After the intervention, these barriers declined markedly, indicating that practical professional development can rapidly improve teachers' instructional confidence and classroom innovation. Similar improvements following targeted teacher training have been reported by Melaku et al. (2025), who found that strengthening teachers' instructional competencies significantly enhanced the implementation

of active learning strategies. Nevertheless, time constraints remained a persistent challenge and became even more evident after training, suggesting that teachers became increasingly aware of the time required to prepare and integrate high-quality instructional materials into their lessons. This finding indicates that improving teacher competence alone may be insufficient unless schools also provide adequate planning time, collaboration opportunities and administrative support to sustain innovative classroom practices. Wang et al. (2025) likewise reported that instructional innovation is more likely to be sustained when schools actively address teachers' workload and organisational constraints.

Differences in teachers' perceptions of school support further reinforce the importance of the institutional environment. Although support improved after the intervention, English teachers continued to perceive greater organisational constraints than Mathematics teachers. This suggests that the successful implementation of waste-to-learning initiatives depends not only on individual teacher competence but also on school leadership, collaborative professional cultures and institutional commitment to innovation. García-Fortes et al. (2025) similarly emphasized that educational innovations involving sustainability are more successfully embedded within schools that actively encourage collaboration, experimentation and continuous professional learning.

Taken together, the findings demonstrate that the intervention achieved more than improvements in technical skills. It enabled teachers to become more creative, confident and resourceful in designing instructional materials from resources already available within their local environments. The study therefore shifts attention from viewing waste materials as inexpensive substitutes for conventional teaching aids to recognizing them as resources that can support instructional innovation when teachers possess the necessary pedagogical competence. Liu et al. (2026) likewise concluded that sustained professional learning strengthens teachers' instructional autonomy by enabling them to make more informed and contextually appropriate pedagogical decisions.

Beyond improving classroom instruction, the findings have broader implications for sustainability education. Integrating recyclable materials into English and Mathematics lessons simultaneously promotes environmental responsibility, creativity and effective resource utilization among teachers and learners. Rather than treating environmental sustainability as a separate area of learning, the intervention demonstrates how sustainable practices can be embedded within everyday classroom activities. This approach enables schools to address educational and environmental objectives concurrently while fostering responsible attitudes towards waste management. Similar conclusions have been drawn by İzgiOnbaşılı and ErcanYalman (2025), who argued that integrating sustainability into routine teaching activities promotes stronger environmental citizenship than isolated environmental programmes.

Although this study provides comprehensive evidence on the effectiveness of teacher training for improving the use of waste materials as instructional resources, some limitations should be acknowledged. The study relied on self-reported data, which may be influenced by social desirability bias, and focused on English and Mathematics teachers within selected primary schools, which may limit the generalizability of the findings to other subject areas and educational settings. In addition, outcomes were assessed shortly after the intervention, making it difficult to determine the long-term sustainability of the observed improvements. Nevertheless, the study provides robust evidence that teacher preparedness and institutional support are more critical than material availability in determining the successful implementation of waste-to-learning initiatives. By integrating evidence on teachers'

perceptions, instructional practices, competencies, implementation barriers and classroom applications, the study contributes a comprehensive understanding of how professional development can promote

## **Conclusion**

This study examined the transformation of waste materials into instructional resources for effective teaching and learning in English and Mathematics in primary schools. The findings indicate that plastic bottles, bottle caps, used papers, cardboard boxes, tin cans, and fabric scraps are widely available within school environments and surrounding communities and can serve as useful instructional resources when teachers possess the necessary skills to utilize them effectively.

The study revealed that, before the intervention, teachers demonstrated limited practical knowledge and experience in converting waste materials into teaching aids despite recognising their availability. English teachers generally reported greater access to waste materials, whereas Mathematics teachers perceived many of these materials as more suitable for instructional use, particularly those that could support practical and manipulative learning activities. In both subject areas, the use of waste-based instructional resources remained modest, and opportunities for learner participation in developing instructional materials were limited.

The training programme produced substantial improvements in teachers' perceptions, competencies, and classroom practices. English teachers demonstrated marked progress in modifying waste materials into visual aids and integrating them into language teaching activities, while Mathematics teachers showed particularly strong gains in assembling teaching models and developing practical instructional resources. Teachers from both subject areas reported increased confidence in independently designing and utilizing waste-based teaching aids and indicated that the intervention positively influenced their classroom practices.

The findings further suggest that the major barriers to the use of waste materials are related more to teacher preparedness and institutional conditions than to the availability of recyclable resources themselves. The considerable decline in knowledge-related challenges following the training confirms the importance of practical professional development in strengthening teachers' capacity to transform locally available materials into effective instructional tools. Nevertheless, time constraints and variations in school support remained important considerations for sustained implementation.

The study contributes to current discussions on resource-based and sustainable education by demonstrating that waste materials can become meaningful instructional resources when supported by appropriate training and enabling school environments. The integration of waste-to-learning approaches offers primary schools a practical means of enhancing instructional effectiveness, promoting learner participation, encouraging creativity, and fostering environmental responsibility. The evidence from this study indicates that continuous professional development and stronger institutional support are essential for sustaining innovative and environmentally responsive teaching practices in English and Mathematics classrooms.

## **Recommendations**

### **Recommendations for practice**

1. Regular teacher training on waste-to-learning approaches should be institutionalized. Education authorities and school administrators should organize periodic workshops and practical sessions to equip teachers with the knowledge and skills required to transform waste materials into effective instructional resources for English and Mathematics teaching.
2. Schools should establish waste material collection and management systems. Dedicated collection points for plastic bottles, cardboard boxes, bottle caps, used papers, and other reusable materials should be created to ensure a steady supply of instructional resources while promoting environmental cleanliness and sustainability.
3. Teachers should actively involve learners in developing instructional materials. Encouraging pupils to participate in the construction of teaching aids can strengthen learner engagement, creativity, collaboration, and practical understanding of classroom concepts while fostering positive environmental attitudes.
4. School leadership should provide institutional support for innovative instructional practices. Head teachers and administrators should allocate time, space, and encouragement for teachers to develop and utilize waste-based instructional resources as part of routine classroom activities.
5. Collaborative sharing of instructional ideas should be promoted among teachers. Professional learning communities and subject-based meetings should include opportunities for teachers to exchange experiences, demonstrate successful practices, and jointly develop instructional materials from locally available waste products.

### **Recommendations for policy**

1. The integration of locally available and recyclable materials into instructional practice should be incorporated into teacher education programmes. Colleges of education and teacher training institutions should include practical modules on the development and use of low-cost instructional materials derived from waste resources.
2. Educational policies should encourage sustainable and resource-based teaching approaches. Ministries of Education and curriculum development agencies should promote the use of environmentally friendly instructional practices that maximize locally available materials and reduce dependence on expensive commercial teaching aids.
3. Funding mechanisms should support school-based innovation in instructional material development. Small grants or resource support programmes could enable schools to establish workshops, storage facilities and demonstration centres for producing teaching materials from recyclable resources.

### **Limitations of the study**

This study was limited to primary school teachers of English and Mathematics in the selected schools, and the findings may therefore not fully represent practices in other subject areas or educational levels. The intervention focused specifically on teachers' knowledge, perceptions,

and self-reported instructional practices relating to the transformation of waste materials into teaching resources. Consequently, caution should be exercised when generalizing the findings beyond similar educational contexts.

The study also relied primarily on questionnaire responses collected before and after the training programme. Although these responses provided valuable insights into changes in teachers' perceptions and practices, they did not include direct classroom observations or independent assessments of the quality and frequency of instructional material use. Future studies could complement self-reported data with observational methods to provide a more comprehensive understanding of how waste-based instructional resources are implemented in classroom settings.

In addition, the present study did not examine the direct effects of waste-derived instructional materials on pupils' academic achievement or learning outcomes. The emphasis was placed on teacher capacity development and instructional preparedness rather than learner performance. Further research could therefore investigate the extent to which the use of such materials influences learners' achievement, engagement, creativity, and retention in English, Mathematics, and other subject areas.

The intervention was conducted over a relatively short period, making it difficult to determine the long-term sustainability of the practices acquired during the training. Future investigations may adopt longitudinal approaches to examine whether teachers continue to utilize waste materials in their instructional activities after extended periods and to identify the factors that facilitate or hinder sustained implementation. Research involving additional subject areas, educational levels, and geographical locations would also provide broader evidence regarding the applicability and effectiveness of waste-to-learning initiatives across diverse educational contexts.

## References

- Afolaranmi, B. (2020). *Educational wastage rate and internal efficiency in public secondary schools in Lagos State, Nigeria* [Working paper]. SSRN. <https://doi.org/10.2139/ssrn.5279249>
- Dong, H., Lio, J., Sherer, R., & Jiang, I. (2021). Some learning theories for medical educators. *Medical Science Educator*, 31(3), 1157–1172. <https://doi.org/10.1007/s40670-021-01270-6>
- García-Fortes, M. Á., Esteve-Guirao, P., Banos-González, I., Valverde-Pérez, M., & Ruiz-Navarro, A. (2025). Waste Education in Teacher Training: Exploring the Role of Context in Shaping Perceptions and Didactic Approaches. *Recycling*, 10(6), 224. <https://doi.org/10.3390/recycling10060224>
- İzgi Onbaşılı, Ü., & Ercan Yalman, F. (2025). Nature-Based Environmental Citizenship Education for Sustainability: A Case Study from Türkiye. *Sustainability*, 17(13), 5917. <https://doi.org/10.3390/su17135917>
- Liu, M., Gurr, D., & Dunn, R. (2026). Educational design research as a form of teacher professional learning: A systematic review. *Asia Pacific Education Review*. Advance online publication. <https://doi.org/10.1007/s12564-025-10104-8>
- Mengistie, S. T., & Belay, M. (2026). Constructivist-teaching and learning practice implementation among middle-level school social studies teachers in West Gojjam,

Northwest Ethiopia. *Cogent Education*, 13(1).  
<https://doi.org/10.1080/2331186X.2026.2680357>

- Melaku, A. K., Ali, A. Y., & Tesfaye, T. M. (2025). Teachers' and students' perception, practices, and challenges of active learning strategy utilization in primary schools of North Wollo Zone, Ethiopia. *Smart Learning Environments*, 12, Article 51. <https://doi.org/10.1186/s40561-025-00391-4>
- Mir, A. H., Alam, M. N., & Modi, A. (2025). Constructivist learning theory: A framework for student-centered instruction in the 21st century classroom. *International Journal of Educational Review, Law and Social Sciences (IJERLAS)*, 5(4), 1273–1283. <https://doi.org/10.54443/ijerlas.v5i4.3456>
- Ndomondo, E. (2024). Instructional resources for innovative history teaching and learning in Tanzania secondary schools: exploring availability and utilization. *Cogent Arts & Humanities*, 11(1). <https://doi.org/10.1080/23311983.2024.2382526>
- Negrín-Medina, M. Á., Bernárdez-Gómez, A., Portela-Prúaño, A., & Marrero-Galván, J. J. (2022). Teachers' perceptions of changes in their professional development as a result of ICT. *Journal of Intelligence*, 10(4), Article 90. <https://doi.org/10.3390/jintelligence10040090>
- Piaget, J. (1952). *The origins of intelligence in children* (M. Cook, Trans.). International Universities Press.
- Schunk, D. H. (2020). *Learning theories: An educational perspective* (8th ed.). Pearson.
- Theodorio, A. O. (2024). Examining the support required by educators for successful technology integration in teacher professional development program. *Cogent Education*, 11(1). <https://doi.org/10.1080/2331186X.2023.2298607>
- UNESCO. (2020). *Education for sustainable development: A roadmap*. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000374802>
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Wang, H., Sun, Y., Wang, W., & Liang, H. (2025). Exploring the relationship between teachers' perceived workload, challenge-hindrance stress, and work engagement: A person-centered approach. *BMC Psychology*, 13(1), Article 201. <https://doi.org/10.1186/s40359-025-02537-y>
- Woolfolk, A. (2022). *Educational psychology* (15th ed.). Pearson.
- Xiong, Z., Song, Y., & Zhu, R. (2025). Pedagogical Strategies for Teaching Environmental Literacy in Secondary School Education: A Systematic Review. *Sustainability*, 17(20), 9104. <https://doi.org/10.3390/su17209104>