African Educational Research Journal
Vol. 14(3), pp. 596-604, August 2026
ISSN: 2354-2160
Full Length Research Paper

Weaving numeracy: The effect of indigenous basketry resources on kindergarten learners' achievement and observed competencies in pre-number concepts

Emmanuel Teku*, Yarhands Dissou Arthur and Emmanuel Akweittey

Department of Mathematics Education, University of Skills Training and Entrepreneurial Development, Post Office Box 1277, Kumasi, Ghana.

Accepted 12 August, 2026

ABSTRACT

Weak foundational numeracy remains a persistent concern in Ghanaian early-grade education, where abstract, verbal methods dominate instruction despite a curriculum that mandates play-based learning with locally available materials. This study examined the effect of integrating indigenous basketry resources into the teaching of pre-number concepts on the academic achievement and observed competencies of Kindergarten Two (KG2) learners. The primary estimand was the total effect of basketry-integrated instruction relative to conventional instruction without manipulatives; the study did not seek to isolate the specifically cultural contribution of the materials. A quasi-experimental, non-equivalent groups pre-test–post-test design was employed with 335 learners in intact classes (181 experimental; 154 control) drawn from public kindergartens across the twelve districts of the Bono Region. The experimental group was taught matching, sorting, comparing, ordering and patterning through structured activities with basketry artefacts for six weeks, while the control group received conventional instruction. Data were collected using parallel performance-based achievement tests and an eleven-item structured observational checklist completed by two trained observers, and analysed using analysis of covariance (ANCOVA) with pre-test scores as a covariate, independent-samples t-tests, supplemented by a cluster-aware sensitivity analysis. The intervention had a statistically significant effect on achievement, $F(1, 332) = 428.00$, $p < 0.001$, partial $\eta^2 = 0.563$ (adjusted means: experimental 7.78, control 4.08), and the experimental group was rated significantly higher on all eleven observed competencies ($d = 2.14$ to 2.49), with the largest differences on mathematical vocabulary, self-correction and unprompted participation. Smaller experimental-group variance descriptively indicated that the benefit extended across the ability range. Culturally grounded manipulative instruction with free, familiar, locally obtainable artefacts substantially outperformed conventional instruction; implications for curriculum provision and teacher preparation are discussed.

Keywords: Ethnomathematics, pre-number concepts, kindergarten, Ghana.

*Corresponding author. E-mail: ekteku@becoled.edu.gh.

INTRODUCTION

Children's early mathematical knowledge is among the strongest predictors of their later achievement, not only in mathematics but across the curriculum (Duncan et al., 2007; Clements and Sarama, 2014). At the heart of this foundation lie the pre-number concepts of matching and one-to-one correspondence, sorting and classification, comparing quantities, ordering and seriation, and patterning, which children must construct before formal number work can be meaningful (Piaget, 1952). Piaget (1952) demonstrated that counting taught in the absence of these logical prerequisites remains rote and fragile; Bruner (1966) showed that young children grasp abstract ideas most securely when instruction begins with enactive, concrete experience; and Vygotsky (1978) added the sociocultural insight that such learning is mediated by the tools, artefacts and practices of the child's own culture.

Ghana's Standards-Based Curriculum for Kindergarten treats early mathematics as a core foundation, explicitly prescribes the pre-number competencies for KG1 and KG2, and directs that teaching be play-based, activity-oriented and resourced with locally available materials (National Council for Curriculum and Assessment [NaCCA], 2019). Yet the mathematics performance of Ghanaian learners has remained persistently low: national and early-grade assessments have found that while most early-grade pupils can perform rote procedural tasks, strikingly few demonstrate conceptual understanding of quantity, relations and patterns (Ministry of Education [MoE], 2016; USAID, 2018). The difficulty, the evidence suggests, is one of pedagogy rather than coverage: instruction that is abstract, teacher-centred and detached from children's lived experience produces rote performance without understanding (Davis, 2016), and classroom observation confirms that recitation and chalkboard work continue to dominate despite the curriculum's play-based intent (USAID, 2018).

Ethnomathematics offers a response. D'Ambrosio (1985) argued that every culture generates authentic mathematical knowledge through its everyday activities, and Gerdes (1988) demonstrated that African craft artefacts such as woven baskets embody "frozen" mathematics: the weaver who alternates strands, repeats motifs and grades sizes is enacting correspondence, classification, seriation and patterning. Ghanaian basketry maps directly onto the pre-number competencies of the kindergarten curriculum: nesting baskets afford ordering and seriation, woven colour bands embody patterning, basket–lid pairs invite one-to-one correspondence, and assorted woven forms support sorting, classification and comparison (Ali and Davis, 2018). Because woven products are familiar objects in homes, farms and markets across Ghana, including the Bono Region, using them as instructional tools can bridge home and school learning environments (Gay, 2010; Ladson-Billings, 1995).

A clear gap nonetheless remains. African ethnomathematics experiments have been conducted at primary and secondary levels (Abiam et al., 2016; Kurumeh, 2006; Unodiaku, 2013), and early childhood intervention studies have used conventional or purpose-built rather than indigenous materials (Clements and Sarama, 2014). The closest Ghanaian study, Ali and Davis (2018), mapped the pre-number affordances of basketry artefacts through qualitative documentation but did not test their instructional effect; the novelty of the present study lies in subjecting that documented potential to controlled experimental comparison at the kindergarten level for the first time. No located study has measured, under controlled comparison, the effect of indigenous basketry resources on kindergarten learners' achievement in pre-number concepts. The present study addressed this gap through two objectives: to find out the academic achievement of KG2 learners taught with indigenous basketry resources and those taught without them, and to examine the observed competencies in pre-number concepts of learners in the two conditions. The null hypothesis stated that there is no statistically significant difference in academic achievement between learners taught using indigenous basketry resources and those taught without them. The study was designed to test an intervention effect which was the total effect of basketry-integrated instruction against conventional instruction as practiced rather than the added value of cultural grounding over other concrete materials, a distinction taken up in the discussion.

Theoretical framework

The study was anchored in D'Ambrosio's (1985) theory of ethnomathematics, which holds that mathematics is not a culture-free body of knowledge, that learners arrive at school already possessing culturally acquired mathematical experience, and that effective instruction builds bridges between the informal mathematics of the learner's culture and the formal mathematics of the curriculum. Gerdes's (1988) African elaboration supplies the operational principle: the educator's task is to "defrost" the mathematics frozen in cultural artefacts and convert it into classroom learning experiences. Three developmental theories specify how this conversion should work for kindergarten learners. Piaget (1952) identified classification, seriation and correspondence, coordinated through one-to-one matching, as the logical operations from which number is constructed, and established that preoperational learners construct these operations through action on concrete objects. Bruner (1966) prescribed the instructional sequence, from enactive manipulation through iconic representation to symbolic language. Vygotsky (1978) elevated the cultural familiarity of the materials from a convenience to a mechanism: culturally meaningful tools, deployed in guided joint activity, mediate mathematical thinking and the acquisition of the mathematical register more powerfully than culturally alien manipulatives. Jointly, the framework predicts that KG2 learners taught pre-number concepts with indigenous basketry resources will outperform learners taught conventionally.

Empirical literature

Three bodies of empirical evidence bear on the study. First, meta-analytic evidence establishes that instruction with concrete manipulatives reliably outperforms abstract-only instruction, with effects strongest for young learners and substantially moderated by instructional guidance (Carbonneau et al., 2013; Sowell, 1989); the field's caution is that manipulatives do not carry meaning by themselves and must be integrated into deliberate, guided activity (Clements, 1999). Second, quasi-experimental studies across Africa consistently find that ethnomathematics-based instruction significantly improves achievement relative to conventional teaching, in Nigerian secondary geometry and mensuration (Kurumeh, 2006), with ethnomathematical materials (Unodiaku, 2013), and among primary pupils (Abiam et al., 2016), while the large-scale evaluation of the Yup'ik-based Math in a Cultural Context programme demonstrated that culturally based curricula can yield measurable achievement gains (Kisker et al., 2012). Within Ghana, Davis (2016) documented the home–school disconnect that such instruction is designed to repair, and Ali and Davis (2018) mapped the pre-number affordances of indigenous basketry artefact by artefact. Third, early childhood research establishes that pre-number competencies develop along teachable progressions that structured concrete activity accelerates, with durable and consequential gains (Clements and Sarama, 2014; Duncan et al., 2007; Papic et al., 2011). What none of this evidence provides is a controlled test of an indigenous African artefact as the instructional medium for pre-number learning at kindergarten, the level at which developmental theory suggests culturally familiar concrete materials should matter most.

MATERIALS AND METHODS

Research design

The study reported here constitutes the quantitative, learner-focused strand of a larger explanatory sequential mixed-methods project. A quasi-experimental, non-equivalent groups pre-test–post-test control group design was adopted because learners were organised in intact classes and random individual assignment was neither feasible nor ethically desirable in natural school settings (Campbell and Stanley, 1963; Shadish et al., 2002). Whole intact classes were assigned to the experimental condition (instruction integrating indigenous basketry resources) or the control condition (conventional instruction as prescribed by the national curriculum). In all, 48 public kindergartens (4 kindergartens from each of the 12 District and Municipalities making a total of 48) contributed 2 intact KG2 classes (in the 4 Kindergartens purposively drawn from each District and Municipalities, 2 Kindergartens were put together to form 2 different groups given 2 intact KG 2 classes), 12 classes (24 schools) to the experimental condition and 12 classes (24 schools) to the control condition since there were Experimental and Control groups in each of the 12 Districts and Municipalities. Allocation was made at the school level: within each district, participating schools were assigned to conditions by purposive sampling technique and experimental and control schools were geographically separated to limit diffusion of the treatment. The independent variable was the method of instruction; the dependent variable was achievement in pre-number concepts, with pre-test scores as covariate. The primary estimand of the study was accordingly the total effect of basketry-integrated instruction relative to conventional instruction without manipulatives, as delivered in ordinary classrooms.

Participants

Demographic characteristics of the learners

This section presents the demographic profile of the KG2 learners who participated in the study. Three background variables were examined: sex, age, and district of school location within the Bono Region. Table 1 summarises the distribution of the 335 learners across these variables.

Table 1. Distribution of Learners by Sex, Age, and District (N = 335).

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	137	40.9
	Female	198	59.1
Age	4 years	34	10.1
	5 years	191	57.0
	6 years and above	110	32.8
District	Sunyani West	35	10.4
	Berekum West	34	10.1
	Dormaa Central	30	9.0
	Tain	30	9.0
	Wenchi	29	8.7
	Berekum East	28	8.4
	Dormaa East	27	8.1
	Jaman South	27	8.1
	Sunyani Municipal	26	7.8

Table 1. Continues.

	Dormaa West	25	7.5
	Jaman North	23	6.9
	Banda	21	6.3
Total		**335**	**100.0**

Source: Field Data, 2026.

Participants were KG2 learners (approximately five to six years of age) in intact classes in public kindergartens drawn from all twelve districts of the Bono Region of Ghana through proportionate stratified sampling of schools. There were 335 learners, who completed both testing occasions, entered the analysis: 181 in the experimental group and 154 in the control group, a retention rate of 100%. The sample comprised 198 girls (59.1%) and 137 boys (40.9%); 57.0% were five years old, the official KG2 entry age. Written informed consent was obtained from parents or guardians, age-appropriate verbal assent from the learners, and institutional permission from the Ghana Education Service and headteachers; codes rather than names were used on all instruments. Ethical approval for the study was granted by University of Skills Training and Entrepreneurial Development.

Intervention

The intervention was delivered over six weeks of regular mathematics instruction by the classroom teachers after orientation by the researchers. The orientation comprised three- day workshop in which the experimental-class teachers were taken through the theoretical rationale, the mapping of basketry artefacts onto the four pre-number domains, and the weekly lesson plans, which were developed collaboratively so that all experimental classes followed a common structure. The implementing teachers were trained kindergarten teachers with Teachers' Cert 'A', Diploma and Bachelor of Education and with more than 5 years of experience, comparable across conditions. Implementation fidelity was supported by periodic, non-evaluative visits by the researchers and by the scheduled lesson observations conducted in both conditions, which provided a continuous record that the defining features of the approach were maintained. Experimental classes were taught the five pre-number domains through structured activities with basketry artefacts—straws, canes, raffia, weaving strips, nesting baskets, basket–lid pairs and finished baskets of varied sizes, colours and patterns—used as manipulatives and contexts: pairing baskets with lids for one-to-one correspondence, sorting woven forms by attribute, comparing basket contents and capacities, ordering graduated nesting baskets, and reading, continuing and creating woven colour-band patterns. Control classes followed the same scheme of work, covered the same content and received the same instructional time through conventional instruction, so that the instructional resources constituted the only systematic difference between conditions.

Instruments

Achievement was measured with two parallel, researcher-constructed performance-based tests covering the five pre-number domains prescribed by the kindergarten curriculum (NaCCA, 2019). Because KG2 learners cannot yet read and write independently, tasks were presented with concrete materials and pictorial items, instructions were delivered orally in the language most familiar to the children, and responses were recorded by trained administrators against a common scoring guide. The post-test was a parallel form of the pre-test, equivalent in structure, domain weighting and difficulty but containing different items. Content validity was established by mapping every item onto the curriculum's pre-number indicators and through expert review.

Reliability was estimated from the pilot administration to 63 KG2 learners in the Bono East Region: the internal consistency of the achievement test was 0.84 against the criterion of .70 (Nunnally and Bernstein, 1994), and the stability of the test over time was examined by re-administering it to the pilot learners.

Observed competencies were measured with an eleven-item structured observational checklist rated on a four-point scale across three constructs: demonstration of pre-number concept skills (four items), engagement and learning behaviours (four items), and independent, collaborative and linguistic competencies (three items). Each learner was rated independently by two trained observers during mathematics lessons in both conditions. Inter-rater agreement on 63 KG 2 learners of the trial observations was high, with exact agreement of 81.0%, $\kappa = .74$, and linear weighted $\kappa_v = .82$, denoting substantial to almost perfect agreement (Cohen, 1960, 1968; Landis and Koch, 1977).

Data analysis

The null hypothesis was tested with a one-way ANCOVA, with post-test achievement as the dependent variable, group as the fixed factor and pre-test achievement as the covariate, at α = 0.05, following screening of the assumptions of normality, homogeneity of variances, homoscedasticity and homogeneity of regression slopes (Field, 2018; Tabachnick and Fidell, 2019). Effect size was reported as partial eta squared against Cohen's (1988) benchmarks. Observational ratings were averaged across the two observers for each learner, and group differences on each item were tested with independent-samples t-tests, with Cohen's d and 95% confidence intervals for the mean difference, and Bonferroni correction applied across the eleven tests (α = 0.0045). Because learners were nested within intact classes, the independence assumption of these analyses is unlikely to hold exactly; a cluster-aware sensitivity analysis was therefore conducted using the design-effect correction of Hedges (2007), in which the obtained test statistics are adjusted for the intraclass correlation of outcomes within classes, and its results are reported alongside the primary analysis.

RESULTS

Effect on achievement

Table 2 presents the post-test descriptive statistics. Learners taught with indigenous basketry resources obtained a markedly higher mean post-test score than their counterparts, a raw difference of 3.70 points, and the smaller experimental-group standard deviation indicates that scores clustered more tightly around the higher mean.

Table 2. Descriptive statistics for post-test achievement scores by group.

Group	Mean	SD	n
Experimental	7.78	1.51	181
Control	4.08	1.76	154
Total	6.08	2.46	335

The experimental group was taught pre-number concepts with indigenous basketry resources; the control group was taught without them.

Assumption screening supported the ANCOVA. Skewness and kurtosis of the score distributions fell within the ±2 band for approximate normality, with graphical evidence corroborating the shape indices; Levene's test found no significant difference between error variances, $F(1, 333) = 1.30$, $p = 0.255$, and the modified Breusch–Pagan test indicated homoscedastic errors, $\chi^2(1) = 2.66$, $p = 0.103$; and the group-by-pre-test interaction was not significant, $F(1, 331) = 0.27$, $p = 0.603$, partial $\eta^2 = 0.001$, satisfying homogeneity of regression slopes (Huitema, 2011). Table 3 presents the ANCOVA.

Table 3. Analysis of covariance on post-test achievement scores by group, with pre-test scores as covariate (N = 335).

Source	Type III SS	df	MS	F	p	Partial η²
Corrected model	1135.83	2	567.92	214.02	< 0.001	0.563
Intercept	4064.92	1	4064.92	1531.86	< 0.001	0.822
Group	1135.73	1	1135.73	428.00	< 0.001	0.563
Pre-test (covariate)	0.07	1	0.07	0.03	0.868	0.000
Error	880.99	332	2.65			
Corrected total	2016.82	334				

$R^2 = 0.563$ (adjusted $R^2 = 0.561$). R^2 here denotes the proportion of variance in post-test scores explained by the full ANCOVA model (group plus covariate); it coincides numerically with the partial η^2 for group only because the covariate contributed virtually nothing to the model. Observed power for the group effect = 1.00 at α = 0.05.

The effect of group on post-test achievement was statistically significant after adjusting for pre-test scores, $F(1, 332) = 428.00$, $p < 0.001$, partial $\eta^2 = 0.563$, and the null hypothesis was rejected. Because ANCOVA is the principal analysis, the covariate-adjusted means are reported: the adjusted mean was 7.78 (SE = 0.12, 95% CI [7.54, 8.02]) for the experimental group and 4.08 (SE = 0.13, 95% CI [3.82, 4.34]) for the control group, an adjusted difference of 3.70 points, 95% CI [3.35, 4.05]; the adjusted and unadjusted means coincide to two decimal places because the covariate was unrelated to the outcome. Group membership accounted for 56.3% of the variance in post-test scores, far beyond the 0.14 benchmark for a large effect (Cohen, 1988); expressed as a standardised mean difference, the advantage is d = 2.28. The pre-test covariate did not significantly predict post-test achievement, $F(1, 332) = 0.03$, $p = 0.868$, a pattern most plausibly reflecting compressed baseline variance, since few kindergarten learners could be expected to perform strongly on pre-number content before instruction in either condition (Miller and Chapman, 2001).

Observed pre-number competencies

Observer agreement was examined before ratings were combined: across the eleven items the two observers differed by a mean of 0.067 scale points in the control condition and 0.088 in the experimental condition, with grand-mean differences of 0.018 and 0.009 respectively, indicating no systematic leniency or severity. Rater-averaged results are presented in Table 4.

Table 4. Observed pre-number competencies by condition, based on rater-averaged scores.

Item	Control mean (SD)	Experimental mean (SD)	MD	t(333)	95% CI of MD	d
Sorts objects by size, shape, colour	2.07 (0.61)	3.38 (0.61)	1.31	19.58	[1.18, 1.44]	2.15
Orders objects according to attributes	2.06 (0.70)	3.43 (0.56)	1.37	19.93	[1.24, 1.50]	2.19
Compares quantities	2.12 (0.66)	3.51 (0.53)	1.39	21.44	[1.26, 1.52]	2.35
Matches pairs of objects correctly	2.06 (0.66)	3.37 (0.56)	1.31	19.69	[1.18, 1.44]	2.16
Adjusts or self-corrects after feedback	2.02 (0.69)	3.49 (0.51)	1.47	22.39	[1.34, 1.60]	2.45
Shows improved engagement and participation	1.99 (0.65)	3.39 (0.54)	1.40	21.51	[1.27, 1.53]	2.36
Remains attentive and focused throughout	1.98 (0.74)	3.43 (0.55)	1.44	20.44	[1.30, 1.58]	2.24
Participates actively without prompting	2.06 (0.72)	3.52 (0.51)	1.46	21.71	[1.33, 1.59]	2.38
Independently initiates pre-number activity	2.01 (0.66)	3.34 (0.57)	1.33	19.84	[1.20, 1.46]	2.18
Works collaboratively with peers	2.02 (0.69)	3.39 (0.60)	1.37	19.55	[1.23, 1.51]	2.14
Uses appropriate mathematical vocabulary	2.10 (0.60)	3.54 (0.56)	1.44	22.67	[1.32, 1.57]	2.49
All eleven items	2.04 (0.67)	3.43 (0.55)	1.39	—	—	2.28

Control n = 154; experimental n = 181. MD = mean difference (experimental − control); d = Cohen's d. Ratings are the mean of two independent observers on a four-point scale. All differences significant at $p < 0.001$ and under Bonferroni correction ($\alpha = 0.0045$); 95% confidence intervals of the mean differences are reported for each item.

Learners taught with indigenous basketry resources were rated higher on every item, with effect sizes from d = 2.14 to d = 2.49 and an overall advantage of 1.39 scale points. The engagement and learning behaviours construct separated the conditions most widely (1.44 scale points), ahead of independent, collaborative and linguistic competencies (1.38) and pre-number concept skills (1.34), and the largest single-item differences concerned the use of appropriate mathematical vocabulary, self-correction after feedback and unprompted participation. The competencies that moved furthest were therefore not the narrowly mathematical ones but those concerning attention, self-regulation, initiative and mathematical talk.

Dispersion of attainment

Control-group variance exceeded experimental-group variance on ten of the eleven observation items, with a mean variance ratio of 1.48 and a maximum of 1.97, and the same pattern appeared on the achievement test, where the experimental group's standard deviation (1.51) was smaller than the control group's (1.76) despite a mean almost twice as high. Because both conditions were rated by two observers and averaged identically, this difference cannot be attributed to differential reduction of measurement error. Descriptively, attainment in the experimental condition clustered more tightly around a higher mean, a pattern consistent with though, in the absence of a formal test of variance differences and of learner-level moderator analyses, not proof of a benefit distributed across the ability range rather than concentrated among learners already performing well.

DISCUSSION

Three findings organise the discussion. First, basketry-integrated instruction produced a very large advantage in pre-number achievement, $F(1, 332) = 428.00$, $p < 0.001$, partial $\eta^2 = 0.563$, an adjusted difference of 3.70 points on the ten-point test. Second, independently observed competencies showed the same advantage on all eleven items ($d = 2.14–2.49$), and the items that separated the conditions most were not the narrowly mathematical skills but mathematical vocabulary, self-correction and unprompted participation. Third, the experimental group's scores were not only higher but less dispersed. The three findings differ instructively in what they measure tested attainment, observed classroom behaviour, and the distribution of attainment and their convergence across different instruments and data sources is itself evidential, since the achievement tests and the observational ratings are not exposed to the same sources of error.

The findings are consistent with the ethnomathematics tradition, which holds that instruction beginning from the mathematics carried within cultural practice offers learners a route into formal content from what they already know (D'Ambrosio, 1985; Gerdes, 1988), and with the developmental account in which children of this age construct number concepts through action upon objects rather than verbal explanation (Bruner, 1966; Piaget, 1952). Sorting, matching, comparing and ordering can be performed upon a woven object but not upon a description of one. A converging explanation comes from cognitive load theory: a culturally familiar material imposes no interpretive cost of its own, leaving working memory available for the mathematical relations the lesson concerns (Sweller, 1988).

The internal pattern of the observation data localises the mechanism, and the differences among the findings repay attention. The largest differences concerned mathematical vocabulary, self-correction and voluntary participation, mapping onto the behavioural, emotional and cognitive dimensions of engagement (Fredricks et al., 2004) and onto the sociocultural account in which the mathematical register is acquired in use, through language attached to joint activity with shared objects (Vygotsky, 1978). That engagement and language moved further than the concept-skill items suggest that the materials operated first on participation and talk, with conceptual attainment following through the activity thereby generated an ordering consistent with Vygotsky's account of mediation and one that the qualitative strand of the wider project was designed to probe. The achievement and observation findings also differ in kind: the former indexes what children could do under standardised assessment, the latter what they did spontaneously in lessons; that both moved together, while the dispersion narrowed, indicates a change in classroom mathematical activity itself rather than test-specific preparation. In the multilingual settings characteristic of Ghanaian kindergartens, activity with familiar shared objects gives comparative and relational vocabulary somewhere to attach (Adler, 2001; Setati, 2005). The dispersion finding is descriptively consistent with widened access rather than amplified advantage, offering distributional support—within the limits noted above—for a claim that culturally responsive pedagogy has more often advanced on theoretical grounds (Gay, 2010; Ladson-Billings, 1995; Moll et al., 1992).

Limitations of the design

The magnitude of the effects requires candid qualification, and five limitations of the design bound the interpretation. First, observers were not blind to condition, and engagement items invite expectancy-influenced judgement (Rosenthal and Rubin, 1978); the uniformity of the observation effects ($d = 2.14–2.49$) is itself consistent with a halo component, and the observational findings should be read with this in mind. Second, the intervention was novel for learners and teachers alike, so novelty cannot be separated from pedagogy within a six-week study; only longer implementations with delayed post-tests can establish durability. Third, learners were assigned and taught in intact classes but analysed as independent cases; the cluster-aware sensitivity analysis indicates that the group effect survives plausible corrections, but the uncorrected standard errors understate uncertainty and the reported significance levels should be read as anti-conservative. Fourth, the control condition involved no manipulatives of any kind, so the comparison estimates the total effect of culturally grounded manipulative teaching against largely verbal teaching; the study cannot, by design, isolate the specifically cultural character of the materials as the active ingredient, and an advantage exceeding two standard deviations well outside the range meta-analyses report for manipulative instruction generally (Carbonneau et al., 2013) should be read in that light. Fifth, the achievement measure was a ten-point researcher-constructed test; although curriculum-mapped and reliable, it samples the five domains briefly, and effects on broader or delayed measures remain to be established. The defensible claim is therefore that culturally grounded manipulative instruction substantially outperformed conventional verbal instruction in these classrooms; isolating the cultural contribution would require a third arm using non-cultural manipulatives.

Applications of the findings

The findings admit direct application at four levels of the system. In the classroom, kindergarten teachers can assemble a basketry mathematics kit at little or no cost nesting baskets, basket–lid pairs, weaving strips, canes and raffia and deploy it through the five structured uses trialled here: pairing for one-to-one correspondence, sorting by attribute, comparing contents and capacities, ordering graduated sizes, and reading and creating woven patterns. In schools and district directorates, the finding that the materials are free, familiar and locally obtainable removes the resource justification for verbal-only teaching; directorates can organise community sourcing of artefacts and school-level demonstration lessons. In teacher preparation, colleges of education can use the intervention's workshop model mapping artefacts to curriculum indicators and collaboratively planning lessons as a replicable module in early-grade mathematics methods courses. In curriculum provision, NaCCA can convert the general directive to use locally available materials into worked exemplars that name indigenous artefacts and specify the pre-number activities they afford, closing the gap between the curriculum's intent and observed classroom practice.

CONCLUSION

Integrating indigenous basketry resources into the teaching of pre-number concepts substantially improved KG2 learners' achievement and observed competencies, and the benefit was descriptively distributed across the ability range. For a system in which teaching and learning materials are chronically underfunded, the practical significance is considerable: the materials are free or nearly free, familiar to learners, and obtainable in any Ghanaian market. Three implications follow. Curriculum authorities should move beyond general encouragement of locally available resources to explicit curricular inclusion of indigenous artefacts with worked exemplars for the pre-number domains; education directorates and schools should provide basketry materials in quantities sufficient for every learner, since a learner waiting for materials is removed from the activity through which the learning is produced; and teacher education should prepare kindergarten teachers to convert indigenous artefacts into structured mathematics lessons. Future research should employ a three-arm design comparing indigenous basketry, conventional manipulatives and no-manipulative instruction, with condition-blind observers, cluster-aware analysis conducted at the class level with multilevel models, larger numbers of classes to support such models, longer duration and delayed post-tests, to establish whether, and by how much, cultural grounding adds to the general benefit of concrete materials.

REFERENCES

Abiam, P. O., Abonyi, O. S., Ugama, J. O., & Okafor, G. (2016). Effects of ethnomathematics-based instructional approach on primary school pupils' achievement in geometry. *Journal of Scientific Research and Reports, 9*(2), 1-15.

Adler, J. (2001). *Teaching Mathematics in Multilingual Classrooms*. Dordrecht: Kluwer Academic Publishers.

Ali, C. A., & Davis, E. K. (2018). Harnessing indigenous basketry resources for prenumber and early number work. *Journal of Education and Learning, 7*(2), 210- 220.

Bruner, J. S. (1966). *Toward a Theory of Instruction*. Cambridge, MA: Harvard University Press.

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and Quasi-Experimental Designs for Research*. Chicago: Rand McNally.

Carbonneau, K. J., Marley, S. C., & Selig, J. P. (2013). A meta-analysis of the efficacy of teaching mathematics with concrete manipulatives. *Journal of Educational Psychology, 105*(2), 380-400.

Clements, D. H. (1999). 'Concrete' manipulatives, concrete ideas. *Contemporary Issues in Early Childhood, 1*(1), 45-60.

Clements, D. H., & Sarama, J. (2014). *Learning and Teaching Early Math: The Learning Trajectories Approach*. 2nd Ed. New York: Routledge.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement, 20*(1), 37-46.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. 2nd Ed. Hillsdale, NJ: Lawrence Erlbaum Associates.

D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics, 5*(1), 44-48.

Davis, E. K. (2016). Cultural influences on Ghanaian primary school pupils' conceptions of mathematics. *Journal of Educational Development and Practice, 7*(1), 1-25.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., Pagani, L. S., Feinstein, L., Engel, M., Brooks-Gunn, J., Sexton, H., Duckworth, K., & Japel, C. (2007). School readiness and later achievement. *Developmental Psychology, 43*(6), 1428-1446.

Field, A. (2018). *Discovering Statistics Using IBM SPSS Statistics*. 5th Ed. London: Sage.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59-109.

Gay, G. (2010). *Culturally Responsive Teaching: Theory, Research, and Practice*. 2nd Ed. New York: Teachers College Press.

Gerdes, P. (1988). On culture, geometrical thinking and mathematics education. *Educational Studies in Mathematics, 19*(2), 137-162.

Hedges, L. V. (2007). Correcting a significance test for clustering. *Journal of Educational and Behavioral Statistics, 32*(2), 151-179.

Huitema, B. E. (2011). *The Analysis of Covariance and Alternatives*. 2nd Ed. Hoboken, NJ: Wiley.

Kisker, E. E., Lipka, J., Adams, B. L., Rickard, A., Andrew-Ihrke, D., Yanez, E. E., & Millard, A. (2012). The potential of a culturally based supplemental mathematics curriculum to improve the mathematics performance of Alaska Native and other students. *Journal for Research in Mathematics Education, 43*(1), 75-113.

Kurumeh, M. S. (2006). Effect of ethnomathematics approach on students' achievement in geometry and mensuration. *Abacus: Journal of the Mathematical Association of Nigeria, 31*(1), 35-44.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3), 465-491.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*(1):159-174.

Miller, G. A., & Chapman, J. P. (2001). Misunderstanding analysis of covariance. *Journal of Abnormal Psychology, 110*(1), 40-48.

Ministry of Education (2016). *National Education Assessment Report*. Accra: Ministry of Education, Ghana.

Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into Practice, 31*(2), 132-141.

National Council for Curriculum and Assessment (2019). *Kindergarten Curriculum for Preschools (KG1 & KG2)*. Accra: Ministry of Education, Ghana.

Papic, M. M., Mulligan, J. T., & Mitchelmore, M. C. (2011). Assessing the development of preschoolers' mathematical patterning. *Journal for Research in Mathematics Education, 42*(3), 237-269.

Piaget, J. (1952). *The Child's Conception of Number*. London: Routledge & Kegan Paul.

Rosenthal, R., & Rubin, D. B. (1978). Interpersonal expectancy effects: The first 345 studies. *Behavioral and Brain Sciences, 1*(3), 377-386.
Setati, M. (2005). Teaching mathematics in a primary multilingual classroom. *Journal for Research in Mathematics Education, 36*(5), 447-466.
Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*. Boston: Houghton Mifflin.
Sowell, E. J. (1989). Effects of manipulative materials in mathematics instruction. *Journal for Research in Mathematics Education, 20*(5), 498-505.
Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*(2), 257-285.
Tabachnick, B. G., & Fidell, L. S. (2019). *Using Multivariate Statistics*. 7th Ed. Boston: Pearson.
Unodiaku, S. S. (2013). Effect of ethno-mathematics teaching materials on students' achievement in mathematics in Enugu State. *Journal of Education and Practice, 4*(23), 70-77.
USAID (2018). *Ghana Early Grade Mathematics Assessment Report*. Washington, DC: United States Agency for International Development.
Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press.

Citation: Teku, E., Arthur, Y. D. and Akweittey, E. (2026). Weaving numeracy: The effect of indigenous basketry resources on kindergarten learners' achievement and observed competencies in pre-number concepts. *African Educational Research Journal, 14*(3), 596-604.