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One Examination Two Routes Cognitive Demand Progression and Examination Prerequisites in the Intended Junior Secondary Algebra Curricula of Ghana and Nigeria

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Abstract

Ghana and Nigeria prepare junior secondary students through different national curricula, yet their senior secondary graduates sit the same West African Senior School Certificate Examination (WASSCE). This study compares the intended algebra curricula feeding into that examination. All 78 algebra statements (33 Ghanaian; 45 Nigerian) were coded for cognitive process (Revised Bloom's Taxonomy) and task demand (Mathematical Task Framework) using explicit decision rules, and each curriculum was mapped against the 21 algebraic-process sub-topics of the WASSCE syllabus. No statement reached Analyze, Evaluate or Create, or "doing mathematics". The curricula did not differ significantly in cognitive process ($\chi^2(2) = 4.92$, $p = .085$) or in their share of high-demand statements (Ghana 55%, Nigeria 44%; $p = .492$). Across Grades 7–9, mean Bloom level rose (OR = 2.72 per grade, $p = .008$) while task demand did not, so progression reflected accumulating procedures rather than deeper reasoning. Two independent coders agreed with this ceiling for every statement but applied a stricter threshold for high demand, so the high-demand share ranged from 15% to 49% across codings. The curricula differed more in content than in demand: Ghana covered 47.6% of the WASSCE algebra foundations, favouring breadth (substitution, change of subject, functions), and Nigeria 38.1%, favouring depth (factorisation, simultaneous equations, algebraic fractions), leaving each senior secondary system with different prerequisites to supply. A shared examination can thus align national curricula at a low level of demand. The findings support a regional framework of junior secondary algebra prerequisites with higher-order demand at every grade.

1. Introduction

Algebra is the bridge between arithmetic and senior secondary mathematics. In Anglophone West Africa, that bridge leads to a common destination. Students in Ghana and Nigeria complete three years of junior secondary schooling, take a national exit examination and, three years later, write the West African Senior School Certificate Examination (WASSCE), set by the West African Examinations Council (WAEC) from a single General Mathematics syllabus (WAEC, n.d.). The two countries therefore share an examination but not a junior secondary curriculum. Ghana's junior high school (JHS) mathematics is specified by the National Council for Curriculum and Assessment (NaCCA, 2020) and Nigeria's junior secondary school (JSS) mathematics by the Nigerian Educational Research and Development Council (NERDC, 2013).

This arrangement raises a question that has received little attention. If two systems build algebraic foundations differently but are judged by the same senior secondary examination, differences between their junior secondary curricula become differences in what senior high schools must supply before the WASSCE. Comparative research shows that national curricula frame algebra very differently even among neighbouring countries (Löfwall Hemmi et al., 2021), and that such differences shape what students have the opportunity to learn (Polikoff et al., 2021; Schmidt et al., 2015). Regional evidence also suggests that intended curricula, instruction and examinations may be aligned around low cognitive demand: Nigerian primary mathematics standards, teaching and examinations concentrate on memorisation and procedures (Adeniran et al., 2023), and about 85% of recent WASSCE items in

Mathematics, English and Biology target remembering, understanding or applying (Ocheola et al., 2026). To the author's knowledge, no study has compared the intended junior secondary algebra curricula of two WAEC member states with reference to the examination they share.

This study makes that comparison on two dimensions of demand and one of content. Cognitive demand is analysed with Revised Bloom's Taxonomy (RBT; Anderson & Krathwohl, 2001) and task demand with the Mathematical Task Framework (MTF; Stein et al., 2000); content is mapped against the WASSCE algebra syllabus. Three research questions guide the analysis:

1. How do the intended JHS/JSS algebra curricula of Ghana and Nigeria compare in cognitive and task demand?
2. How do cognitive and task demand progress across Grades 7–9 in each curriculum?
3. To what extent does each curriculum supply the algebraic foundations assumed by the WASSCE General Mathematics syllabus?

The argument developed is that the two curricula differ less in how demanding their algebra is than in which algebra they specify. Because both feed into one examination, those content differences translate into different preparatory burdens for senior high schools in each country, and the shared ceiling of demand reflects an alignment with the examination that is coherent but low.

2. Context: Two exit examinations, one WASSCE

Both countries follow a 6-3-3 structure of six years of primary, three of junior secondary and three of senior secondary schooling (Clark, n.d.). Their routes through Grade 9 differ (Table 1).

Table 1
Junior secondary arrangements in Ghana and Nigeria

Feature	Ghana	Nigeria
Junior secondary phase	Junior High School (JHS 1–3), Basic 7–9	Junior Secondary School (JSS 1–3)
Curriculum authority	NaCCA; Common Core Programme mathematics curriculum (NaCCA, 2020)	NERDC; junior secondary mathematics curriculum (NERDC, 2013)
Algebra organisation	Strand "Algebra" with three sub-strands spiralled across all three grades	Theme "Algebraic Processes" with topics placed in one or two grades
Exit examination	Basic Education Certificate Examination (BECE), delivered by WAEC (Clark, n.d.)	BECE set by state ministries of education under NECO supervision; NECO examines federal schools directly (Osoro, 2026)
Senior secondary examination	WASSCE (WAEC)	WASSCE (WAEC) or NECO's Senior School Certificate Examination (Clark, n.d.)

The WASSCE is the point of convergence. WAEC administers it in Ghana, Nigeria, Sierra Leone, Liberia and The Gambia (Clark, n.d.), and General Mathematics ("Core Mathematics" in Ghana) is examined from one syllabus. The syllabus states that it "is not intended to be used as a teaching syllabus" and advises teachers to use "their own National teaching syllabuses or curricula"; of the eight longer Section B questions in Paper 2, only two may draw on content that "may not be peculiar to candidates' home countries" (WAEC, n.d.). Since the COVID-19 disruption, Ghana has sat the WASSCE in August–September while other member states returned to May–June, so Ghanaian candidates answer different papers on the same content areas, set by WAEC's international panel to a common standard (Fact-Check Ghana, 2023).

The common syllabus does not provide a common starting point. Its algebraic-processes section presupposes fluency with expressions, substitution, factorisation, linear and simultaneous equations, change of subject, inequalities, algebraic fractions and functions before it introduces quadratic and two-variable work (WAEC, n.d.). Each country's junior secondary curriculum supplies a subset of these assumptions, as Section 6.4 shows.

Outcomes are reported differently in the two countries, so direct comparison is not possible. In Ghana, the share of school candidates obtaining A1–C6 in Core Mathematics rose from 54.11% in 2021 to 66.86% in 2024 (WAEC Ghana, 2024). In Nigeria, WAEC reports a composite measure: of the 1,805,216 school candidates who sat the 2024 WASSCE, 72.12% obtained credits in at least five subjects including English and Mathematics (Tobi, 2024). Nigeria introduced revised basic and secondary curricula from the 2025/2026 session to reduce content overload (Voice of Nigeria, 2025); the NERDC (2013) curriculum analysed here therefore governs the cohorts who will sit the WASSCE until about 2030.

3. Literature review

3.1 Cognitive demand in intended curricula

Recent curriculum analyses use RBT to code the cognitive processes that curriculum statements require. Tugores Blanco et al. (2025) coded 678 cognitive processes in 186 assessment criteria of Galicia's secondary mathematics curriculum and found Apply most common, with mean demand only slightly above the scale midpoint. Tugores et al. (2025) found that Spanish and Portuguese primary mathematics curricula had different cognitive profiles and progression patterns despite similar overall demand, and Sabita and Pramesti (2026) found Indonesia's lower secondary curriculum dominated by Apply and Singapore's by Evaluate. Three points from this work inform the present study: comparison requires coding the cognitive act rather than counting verbs; similar mean demand can mask different distributions; and progression across grades is a separate question from overall level.

In African systems, the dominant finding is concentration at lower levels. Using the Surveys of Enacted Curriculum, Adeniran et al. (2023) found that Nigerian primary mathematics standards placed about 72% of their emphasis on memorising and performing procedures, and that standards, instruction and

examinations were aligned with one another at low demand; Atuhurra and Kaffenberger (2022) reported low coherence among standards, examinations and instruction in Tanzania and Uganda. Kirei and Maro (2021) found that Tanzanian secondary chemistry examinations matched the curriculum but that both concentrated on lower Bloom levels, and Ocheola et al. (2026) found that 84.8% of 1,125 WASSCE Mathematics, English and Biology items from 2019–2023 targeted remembering, understanding or applying.

3.2 Task demand and the Mathematical Task Framework

The MTF distinguishes low-demand tasks (memorisation; procedures without connections) from high-demand tasks (procedures with connections; doing mathematics) (Stein et al., 2000). Classroom research shows that high-demand tasks often decline into routine procedures during enactment (Henningsen & Stein, 1997) and that maintaining their demand requires sustained teacher support (Boston & Smith, 2009). The framework remains in active use: Ekol and Mlotshwa (2022) rated probability tasks in a South African online textbook, and Wakhata et al. (2023) found that instruction organised around the MTF levels improved Ugandan Grade 11 students' problem solving ($d = 0.81$). Polikoff et al. (2021) reported low cognitive demand across widely used Grade 8 textbooks in California. Most MTF studies analyse tasks; this study treats each curriculum statement as a signal of the potential demand of the tasks it licenses.

3.3 Algebra curricula and progression

Cross-national studies show that algebra is organised differently even in culturally similar systems. Löfwall Hemmi et al. (2021) identified distinct approaches in the Grade 1–9 curricula of Estonia, Finland and Sweden, and Tonnesen (2024) contrasted the introduction of algebra in Japanese and Danish lower secondary textbooks. Veasna (2025) found that, unlike Singapore's, Cambodia's intended geometry curriculum lacked coherence across grades. Learning-progression research gives functional thinking and generalisation an early and continuing place. Sun et al. (2023) identified four ordered levels of early algebraic thinking among 526 Shanghai students, with generalisation rather than symbol use driving progress; Utami et al. (2023) found that Grade 9 students who used a recursive approach to patterns could not express general rules symbolically, whereas those using a correspondence approach could; and Ramírez Uclés et al. (2022) found that 6th graders' difficulties with quadratic functions lay mainly in expressing structure. A review of 36 studies recommended multiple representations and non-routine activities to develop algebraic thinking (Sibgatullin et al., 2022). For curriculum analysis, the presence or absence of patterns, functions and generalisation in a junior secondary curriculum is therefore a substantive design choice.

3.4 West African evidence on algebra learning

Studies of Ghanaian JHS learners find persistent difficulty with comprehension and transformation in algebra. Kenney and Ntow (2024) analysed the errors of 171 Grade 7 learners using Newman's framework, and Baidoo (2025) found comprehension errors in 77.5% and transformation errors in 60.5% of 200 learners' responses to algebra tasks. In Nigeria, Ogbu (2025) found that secondary students

could represent unknowns with letters but struggled to form linear and quadratic expressions and to set up simultaneous equations from word problems. Implementation studies in Ghana point to teacher, learner and school factors in delivering the Common Core Programme (Abubakari et al., 2025) and to teachers' self-efficacy in implementing the earlier standards-based curriculum (Agormedah et al., 2022).

3.5 Gap addressed

Three gaps follow. Cognitive-demand studies of mathematics curricula have rarely examined West African junior secondary algebra, and none has compared two WAEC member states. Curriculum comparisons seldom combine a cognitive-process framework with a task-demand framework, although the two can disagree. And studies of the WASSCE have examined its items (Ocheola et al., 2026) but not the junior secondary curricula that supply its prerequisites. This study addresses all three.

4. Theoretical framework

The study uses two frameworks for demand and two principles for comparison.

Revised Bloom's Taxonomy. Anderson and Krathwohl (2001) separate a cognitive-process dimension (Remember, Understand, Apply, Analyze, Evaluate, Create) from a knowledge dimension (factual, conceptual, procedural, metacognitive). Each process has named sub-processes, such as translating and interpreting under Understand and executing and implementing under Apply. Because the processes are ordered by assumed complexity, they can be scored 1–6 and compared as an ordinal variable.

Mathematical Task Framework. Stein et al. (2000) classify mathematical tasks by the thinking they require. Memorisation (LM) and procedures without connections (PNC) are low-demand; procedures with connections (PWC), which use procedures to build understanding of concepts and links between representations, and doing mathematics (DM), which requires non-algorithmic exploration, are high-demand. The MTF is not hierarchical in the sense of RBT: a translation statement (Understand) can be high-demand because it connects representations, and an execution statement (Apply) can be low-demand because it calls for a practised procedure. The framework was designed for tasks; applied to curriculum statements, it indicates the potential demand of the tasks a statement licenses, not the demand students experience. Using both frameworks allows the analysis to test whether "higher on Bloom" and "higher in task demand" coincide.

Coherence and progression. A coherent curriculum sequences topics so that each grade builds on earlier ones and deepens over time (Schmidt et al., 2005). Progression is examined in two senses: whether demand rises across Grades 7–9, and whether content threads continue, deepen or stop.

Alignment and opportunity to learn. Alignment frameworks compare curricula, instruction and assessment on content and cognitive demand together (Porter, 2002). The WASSCE syllabus is taken as a common reference standard, and coverage of its algebraic-process foundations is read as the opportunity to learn that each junior secondary curriculum provides for the senior secondary examination (Polikoff et al., 2021).

5. Methodology

5.1 Research design

The study was a comparative document analysis. Directed qualitative content analysis (Hsieh & Shannon, 2005) applied categories from RBT and the MTF to every algebra statement in each curriculum, and the codes were then quantified so that distributions could be compared. A third strand mapped each curriculum against the WASSCE algebra syllabus. The object of study was the intended curriculum as written in official documents; enacted and attained curricula were outside its scope.

5.2 Data sources

Three documents were analysed: (a) the Algebra strand of Ghana's JHS mathematics curriculum (Basic 7–9), comprising three sub-strands (Patterns and Relations; Algebraic Expressions; Variables and Equations), each with one content standard and three to five indicators per grade (NaCCA, 2020); (b) the Algebraic Processes theme of Nigeria's JSS 1–3 mathematics curriculum, comprising ten topics, each with numbered performance objectives and content statements (NERDC, 2013); and (c) Section B, "Algebraic Processes", of the WAEC General Mathematics/Mathematics (Core) syllabus, with nine topics and 21 sub-topics (WAEC, n.d.). The Ghanaian and Nigerian statements were transcribed into a structured workbook, one row per statement, retaining their original wording and codes.

5.3 Units of analysis

The unit of analysis was the smallest expected-learning statement in each curriculum: indicators in Ghana (n = 33) and performance objectives in Nigeria (n = 45). Ghanaian content standards and Nigerian content statements were used only to interpret scope, so that each country contributed statements at a similar grain; for example, Ghana's indicator "Solve linear equations in one variable" and Nigeria's objective "Solve problems on simple equations" each specify a single expected performance. Grades were aligned as Grade 7 (JHS 1/JSS 1), Grade 8 (JHS 2/JSS 2) and Grade 9 (JHS 3/JSS 3). Table 2 shows the corpus.

Table 2
Corpus of algebra statements by country and grade

Grade	Ghana indicators	Nigeria objectives	Total
Grade 7	13	16	29
Grade 8	10	18	28
Grade 9	10	11	21
Total	33	45	78

Sources

NaCCA (2020); NERDC (2013).

5.4 Coding frameworks and decision rules

Each statement was coded for RBT cognitive process (scored 1–6) and MTF level, from which MTF demand (high or low) followed. Codes were assigned to the cognitive act the statement requires, not to its surface verb: Ghana's "Create simple algebraic expressions … to translate a set of instructions", for example, requires translating rather than creating. A statement with two verbs was coded by its terminal process. Table 3 shows the decision rules. The RBT knowledge dimension follows from the rule applied (Table 3).

Table 3
Decision rules for coding curriculum statements

Rule	Statement type (example)	RBT process	Knowledge	MTF
R1	Identify or recognise a term, axis or form ("Identify the coefficient of a given algebraic term")	Remember–Recognising	Factual	LM
R2	Translate, represent, describe, explain, interpret or illustrate ("Translate word problems to linear equations")	Understand	Conceptual	PWC
R3	Perform, solve, factorise or plot with no context ("Solve simple linear inequalities")	Apply–Executing	Procedural	PNC
R4	Solve word or real-life problems, model, or use a graph to solve ("Use graphs of linear relations to solve real life problems")	Apply–Implementing	Conceptual	PWC
R5	"… and use it to solve problems" with no context named	Apply–Executing	Procedural	PNC
R6	Nigerian "quantitative aptitude/reasoning" objectives	Apply–Implementing	Conceptual	PWC

Note. R5 assumes that unspecified "problems" are routine. R6 is the least certain rule, because the four objectives it covers could be coded Analyze/DM depending on the items used to teach them; it is tested in Section 6.5.

5.5 WASSCE coverage mapping

Each of the 21 WASSCE algebraic-process sub-topics was scored for each curriculum as 2 (full) if a statement specified it at the level the syllabus assumes; 1 (partial) if a related foundation was specified but not the named form, method or extension; and 0 (none) if it was not addressed. Ghana's "factorize expressions that have simple binomial as a factor", for example, was scored 1 against the sub-topic that names grouping, difference of two squares and quadratic factorisation, whereas Nigeria's factorisation content, which names all four forms, was scored 2. Coverage was summarised as a percentage of the maximum score (42).

5.6 Coding procedure and reliability

The author developed the decision rules in Table 3 through familiarisation with the three documents and then coded all 78 statements and the 42 coverage cells, recording a confidence rating for each decision; 12 Ghanaian and 11 Nigerian codes were rated medium or low confidence. These rule-based codes were used in all analyses.

To examine how consistently the rules could be applied, two independent coders, a curriculum expert at the National Council for Curriculum and Assessment (NaCCA), Ghana, and a mathematics education researcher at Hiroshima University, each coded all 78 statements for RBT process and MTF level from a blinded, randomly ordered file that contained the decision rules and a worked example from outside the corpus. Agreement was summarised as percentage agreement, Cohen's (1960) κ and Gwet's (2008) AC1, with 95% confidence intervals from 5,000 bootstrap resamples; AC1 is reported alongside κ because the codes were concentrated in a few categories, a condition under which κ can be low even when agreement is high (Feinstein & Cicchetti, 1990). The two independent coders agreed substantially with each other (Landis & Koch, 1977) on RBT process (86%; κ = 0.68, 95% CI [0.50, 0.84]; AC1 = 0.85, 95% CI [0.76, 0.93]) and MTF level (88%; κ = 0.66, 95% CI [0.45, 0.84]; AC1 = 0.87, 95% CI [0.78, 0.94]). Their agreement with the rule-based codes was lower: 63% and 69% for RBT process (κ = 0.19 and 0.20; AC1 = 0.59 and 0.67) and 47% and 50% for MTF level (κ = 0.02 and 0.06; AC1 = 0.38 and 0.40).

The disagreement was systematic rather than random. All three codings agreed for every statement (78 of 78) that no statement reached Analyze, Evaluate or Create, and that none reached doing mathematics, so the study's central finding does not depend on who coded. Where the rules called for executing a practised procedure (Rule R3; 35 statements), the independent coders matched the rule-based MTF codes for 31 and 28 statements (89% and 80%). Disagreement was concentrated in the 22 statements that ask learners to solve word or real-life problems or to use a graph (Rule R4), where they matched the rule-based codes for only 3 and 7, and it ran almost entirely in one direction: 32 of the NaCCA coder's 41 MTF disagreements and 27 of the Hiroshima University coder's 39 were statements that the rules class as procedures with connections and the coders classed as procedures without connections. The coders therefore applied a consistently stricter threshold for "connections" than the written rules, at a boundary that is difficult to judge from task text alone (Fox et al., 2026) and on which exact agreement in cognitive-demand ratings is often modest (Boston & Wolf, 2006). Because the coders' agreed codes also departed from the written rules in a substantial number of cases, including several of the examples given in Table 3, the rule-based codes were retained for analysis, and the independent codes were used to test which findings depend on this threshold and to bound the estimates of task demand (Section 6.5). The WASSCE coverage scores were assigned by the author.

5.7 Statistical analysis

The 78 statements are a census of the two curricula rather than a sample, so the analysis is primarily descriptive, and effect sizes are the main basis for interpretation. Inferential tests are used as a secondary check on whether observed differences exceed what would be expected if country or grade labels were unrelated to the codes (Agresti, 2013). Analyses were run in Python 3 (SciPy 1.18; statsmodels 0.15), with α = .05 (two-tailed).

For RQ1, Pearson χ^2 tests compared the distributions of RBT process and MTF level between countries (the knowledge dimension, which follows from the decision rules, is reported descriptively); because some expected counts were below 5, p-values were confirmed with Monte Carlo permutation tests (10,000 permutations, seed 2026), and Cramér's V was reported as the effect size. Fisher's exact test compared the share of high-demand statements, with the odds ratio and its 95% confidence interval, and proportions are reported with Wilson 95% intervals. Mann–Whitney U tests compared RBT level (1–6) and MTF level (LM = 1 to DM = 4), with the rank-biserial correlation (r_rb) as the effect size, and Spearman's ρ assessed concordance between the two frameworks. For RQ2, Kruskal–Wallis tests, Spearman's ρ and Cochran–Armitage trend tests examined change across grades within each country; pooled across countries, an ordinal (proportional-odds) logistic regression modelled RBT level on country and grade, and a binary logistic regression modelled high demand on country, grade and their interaction. For RQ3, a Wilcoxon signed-rank test compared the paired 0–2 coverage scores of the 21 sub-topics, with a sign test as a check. Sensitivity analyses repeated the main tests with the four quantitative-aptitude objectives recoded as Analyze/DM, and with each independent coder's codes, and the codes on which the two coders agreed (with their 19 disagreements resolved by the decision rules), in place of the rule-based codes.

With 33 and 45 statements, a two-sided test at $\alpha = .05$ has 80% power to detect a difference of about 30 percentage points between two proportions near 50% (Cohen's h = 0.64). Non-significant results are therefore interpreted through their effect sizes and confidence intervals, not as evidence of equivalence.

5.8 Trustworthiness and ethics

Trustworthiness was supported by explicit decision rules, a confidence rating for every decision, independent coding of all statements by two further coders, an audit trail of all data corrections, and sensitivity analyses. The coded workbook, analysis script and decision rules are available in an open repository (see Data availability). The study used publicly available policy documents and involved no human participants, so ethical approval was not required.

6. Results

6.1 Cognitive demand (RQ1)

Both curricula were confined to the three lowest RBT processes: none of the 78 statements was coded Analyze, Evaluate or Create, and none drew on metacognitive knowledge (Table 4). Apply accounted for 70% of Ghana's statements and 76% of Nigeria's.

Table 4
Distribution of RBT cognitive processes and knowledge dimensions, n (%)

Code	Ghana (n = 33)	Nigeria (n = 45)	Total (n = 78)
Remember	0 (0.0)	4 (8.9)	4 (5.1)
Understand	10 (30.3)	7 (15.6)	17 (21.8)
Apply	23 (69.7)	34 (75.6)	57 (73.1)
Analyze / Evaluate / Create	0 (0.0)	0 (0.0)	0 (0.0)
Mean RBT level (1–6)	2.70	2.67	2.68
Factual knowledge	0 (0.0)	4 (8.9)	4 (5.1)
Conceptual knowledge	17 (51.5)	21 (46.7)	38 (48.7)
Procedural knowledge	16 (48.5)	20 (44.4)	36 (46.2)
Metacognitive knowledge	0 (0.0)	0 (0.0)	0 (0.0)

Note. The knowledge dimension follows from the decision rule applied to each statement (Table 3) and is therefore reported descriptively rather than tested.

The two profiles differ in shape rather than level. Ghana's lower-level demand took the form of Understand statements, such as translating word problems into equations, describing rules and interpreting graphs, and Ghana had about twice Nigeria's share of these (30.3%, 95% CI [17.4, 47.3], against 15.6% [7.7, 28.8]; Fisher's exact p = .166). Nigeria was the only curriculum with Remember statements, which ask learners to identify coefficients, axes and inequalities (p = .133). The association between country and cognitive process did not reach significance, with a small-to-moderate effect (Table 5), and mean RBT levels were almost identical (2.70 vs 2.67). Knowledge types were split almost evenly between conceptual and procedural in both curricula.

Table 5
Tests of association between country and coding categories

Test	Statistic	p (asymptotic)	p (permutation)	Effect size
Country × RBT process	$\chi^2(2) = 4.92$	.085	.088	V = .25
Country × MTF level	$\chi^2(2) = 3.34$	.188	.217	V = .21
Country × MTF demand (high/low)	Fisher's exact	.492	—	OR = 1.50 [0.61, 3.70]
RBT level, Ghana vs Nigeria	U = 719	.764	—	r_rb = − .03
MTF level, Ghana vs Nigeria	U = 847.5	.233	—	r_rb = .14

Note. Permutation p-values are from 10,000 Monte Carlo permutations of country labels. OR = odds of a high-demand statement in Ghana relative to Nigeria.

6.2 Task demand and framework concordance (RQ1)

On the MTF, 54.5% of Ghana's statements (18 of 33; 95% CI [38.0, 70.2]) and 44.4% of Nigeria's (20 of 45; [30.9, 58.8]) were high-demand, all at the PWC level; no statement in either curriculum reached doing mathematics. The difference was not statistically significant (OR = 1.50, 95% CI [0.61, 3.70], p = .492).

The two frameworks did not rank statements in the same order. RBT level and MTF level were weakly and non-significantly negatively correlated (ρ = −.15, p = .178). Of the 17 Understand statements, 16 were high-demand, because translating and interpreting connect representations; of the 57 Apply statements, 35 were low-demand, because most called for executing a practised procedure. In both curricula, the RBT process most associated with high task demand was therefore Understand, not the "higher" process Apply.

6.3 Progression across Grades 7–9 (RQ2)

Across Grades 7–9 the two frameworks moved in different directions (Fig. 1; Table 6). Mean RBT level rose in both countries, significantly in Nigeria (from 2.44 in JSS 1 to 3.00 in JSS 3; ρ = .38, p = .011) though not in Ghana alone (from 2.54 to 2.80; ρ = .25, p = .160). Pooled across countries, each additional grade multiplied the odds of a higher RBT level by 2.72 (95% CI [1.30, 5.69], p = .008). The share of high-demand statements, by contrast, did not rise in either country: it was highest in Grade 7 (Ghana 69%, Nigeria 50%), dropped in Grade 8 (40% and 39%) and only partly recovered in Grade 9 (50% and 45%). Grade had no effect on the odds of a high-demand statement (OR = 0.77, p = .369), and the country × grade interaction was not significant (p = .600). The rise in RBT level reflects the replacement of Remember and Understand statements by Apply statements: Nigeria's JSS 3 algebra is entirely Apply.

Table 6
Tests of progression across Grades 7–9

Test	Ghana	Nigeria	Pooled model
Kruskal–Wallis, RBT level	H(2) = 2.47, p = .290	H(2) = 6.28, p = .043	—
Spearman ρ, grade × RBT level	.25, p = .160	.38, p = .011	—
Spearman ρ, grade × MTF level	−.18, p = .316	.00, p = .981	—
Cochran–Armitage trend, high demand	z = − 1.00, p = .319	z = − 0.30, p = .761	—
Ordinal logistic, RBT level: grade	—	—	OR = 2.72 [1.30, 5.69], p = .008
Ordinal logistic, RBT level: Nigeria	—	—	OR = 1.15 [0.41, 3.27], p = .790
Binary logistic, high demand: grade	—	—	OR = 0.77 [0.44, 1.36], p = .369
Binary logistic, high demand: Nigeria	—	—	OR = 0.66 [0.27, 1.64], p = .370
Binary logistic: country × grade interaction	—	—	p = .600

Note. RBT = Revised Bloom's Taxonomy; MTF = Mathematical Task Framework; high demand = procedures with connections or doing mathematics. ρ = Spearman's rank correlation. In the pooled models, grade is entered as Grades 7–9 and Ghana is the reference country; OR = odds ratio [95% CI]. Tests are two-tailed (α = .05).

The content threads explain this pattern. Ghana spirals three sub-strands through all three grades, but its high-demand work is concentrated in JHS 1, where learners describe and predict from patterns and translate between words and symbols. Its equation thread also stops expanding after JHS 1: equations are limited to the form x + a = b, and later grades add inequalities and graphical methods but no new equation forms. Nigeria places topics in blocks: patterns and relations are absent, inequalities appear only in JSS 2, and factorisation recurs in JSS 2 and JSS 3 with identical verbs. In both curricula, most high-demand statements in Grades 8 and 9 are graph-interpretation, real-life or word-problem objectives added after the corresponding procedures (7 of Ghana's 9 and 9 of Nigeria's 12).

6.4 Coverage of WASSCE algebra foundations (RQ3)

Table 7 gives the score awarded to each curriculum for each of the 21 WASSCE algebraic-process sub-topics, together with the coverage totals: 20 of 42 (47.6%) for Ghana and 16 of 42 (38.1%) for Nigeria.

Table 7
Coverage of WASSCE algebraic-process sub-topics by the junior secondary curricula (2 = full, 1 = partial, 0 = none)

WASSCE sub-topic (WAEC, n.d.)	Ghana	Nigeria
B(a)(i) Formulating expressions from situations	2	2
B(a)(ii) Evaluating expressions by substitution	2	0
B(b)(i) Expansion	2	2
B(b)(ii) Factorisation (common factor, grouping, difference of two squares, quadratic)	1	2
B(b)(iii) Binary operations	0	0
B(c)(i) Linear equations in one variable	1	2
B(c)(ii) Simultaneous linear equations (elimination, substitution, graphical)	1	2
B(d)(i) Change of subject of a formula	2	0
B(d)(ii) Substitution into formulae	2	0
B(e)(i)–(iii) Quadratic equations: solving, forming, applying (3 sub-topics)	0, 0, 0	0, 0, 0
B(f)(i) Tables of values, plotting and interpreting graphs	1	1
B(f)(ii) Graphical solution of a linear–quadratic pair	1	1
B(f)(iii) Gradient, intercepts, turning points, symmetry	1	0
B(g)(i) Linear inequalities in one variable; number line	2	2
B(g)(ii)–(iii) Two-variable and simultaneous inequalities; linear programming	0, 0	0, 0
B(h)(i) Algebraic fractions with monomial denominators	1	2
B(h)(ii) Algebraic fractions with binomial denominators	0	0
B(i) Functions and relations: mappings and rules	1	0
Coverage score (of 42)	20 (47.6%)	16 (38.1%)

Sources

NaCCA (2020); NERDC (2013); WAEC (n.d.).

Ghana addressed 14 of the 21 sub-topics at least partially and Nigeria 9, and all nine of Nigeria's were among Ghana's 14 (Jaccard overlap = .64). For full coverage the picture reverses: Nigeria fully specified seven sub-topics and Ghana six, but only three were fully covered by both (formulating expressions,

expansion, one-variable inequalities; Jaccard overlap = .30). Ghana scored higher on five sub-topics (substitution in expressions and formulae, change of subject, gradient and intercepts, functions) and Nigeria on four (factorisation, linear equations, simultaneous equations, algebraic fractions). The paired difference was not significant (Wilcoxon T = 14, p = .297; sign test p = 1.00). Neither curriculum covered seven sub-topics, mostly quadratic and two-variable work, which therefore fall wholly to senior secondary school.

6.5 Sensitivity analyses

Recoding Nigeria's four quantitative-aptitude objectives as Analyze/DM (Rule R6) strengthened the association between country and RBT process to the margin of significance ($\chi^2(3) = 7.79$, p = .051; permutation p = .046; V = .32), but mean RBT levels remained similar (2.70 vs 2.76; U = 673, p = .396). The MTF results did not change, because these objectives were already coded as high-demand, and the rise in RBT level across grades remained (pooled OR = 1.93, p = .037).

Using the independent coders' codes in place of the rule-based codes (Section 5.6) tested which findings depend on how the rules are applied. Three findings held in every coding: no statement above Apply or at doing mathematics; no significant country difference in cognitive process (p = .534 with the coders' agreed codes; p = .899 and .727 with each coder's codes); and no rise in task demand across grades. The level of task demand did not hold. With the coders' agreed codes, only 15.2% of Ghana's and 33.3% of Nigeria's statements were high-demand (p = .114), and with each coder's codes 9.1% and 20.0% (p = .221) or 18.2% and 33.3% (p = .197); the direction of the country difference therefore reversed, although it was not significant in any coding. With the agreed codes, Ghana's high-demand statements fell from 31% in JHS 1 to none in JHS 3 (p = .038). The rise in RBT level held with the agreed codes (OR = 2.12, p = .048) but not with either coder's codes alone (OR = 1.15, p = .645; OR = 1.43, p = .320). Taken together, the codings bound the share of high-demand statements between 15% and 49% overall (Ghana 9–55%; Nigeria 20–44%). The shared ceiling, the absence of a country difference and the absence of growth in task demand are therefore robust to who applies the rules; the exact share of high-demand statements and the rise in RBT level depend on the threshold for "connections" and should be read with caution.

7. Discussion

7.1 Aligned at the floor

The first finding is a shared ceiling. Neither curriculum asks junior secondary students to analyse, evaluate, create, justify or generalise in algebra, and neither reaches doing mathematics; nearly three-quarters of all statements require Apply, and every high-demand statement sits at the level of procedures with connections. The two countries are statistically indistinguishable on every measure of demand, with small-to-moderate effect sizes and confidence intervals wide enough to include both no difference and moderate differences. This fits regional evidence that standards, teaching and examinations are aligned at low cognitive demand (Adeniran et al., 2023; Kirei & Maro, 2021), and it matches the profile of the examination both curricula feed into (Ocheola et al., 2026). In the alignment sense, both curricula fit the

WASSCE well, but they fit it at the floor: students reach senior high school having been asked mainly to execute procedures, and the examination largely rewards them for doing so. The cost falls on the minority of WASSCE items, and the post-secondary mathematics, that require multi-step reasoning neither curriculum explicitly develops.

The pattern is not peculiar to West Africa. Alignment studies elsewhere show that coherence among standards, examinations and teaching, where it exists, tends to form around lower-order demand (Atuhurra & Kaffenberger, 2022). Evidence from high-performing systems is a useful corrective to the assumption that procedural emphasis is itself the problem: Porter et al. (2011) found that the mathematics standards of Finland, Japan and Singapore placed more emphasis on performing procedures than the United States Common Core did. Procedural fluency is a necessary strand of proficiency. What distinguishes the Ghanaian and Nigerian algebra curricula is not that they contain procedural statements but that they contain nothing above Apply and nothing at the level of doing mathematics. Alignment is therefore a neutral property: it can carry high demand through a system as readily as it can lock in low demand.

7.2 Progression without rising demand

The second finding concerns what "progression" means. Judged by RBT alone, both curricula progress: mean level rises across grades, significantly in Nigeria and in the pooled model. Judged by task demand, neither does: high-demand statements are most frequent in Grade 7, and their share never recovers to that level. The two frameworks were weakly negatively correlated because Apply ranks above Understand on RBT, whereas translating and interpreting connect representations. The Bloom index therefore rises as statements move from understanding to executing, not as reasoning deepens. This echoes Tugores et al.'s (2025) caution that similar averages can hide different profiles, and it has a methodological implication: single-framework analyses of curricula may report progression where task-level demand is flat or falling. Because the rise in RBT level was not stable across all codings (Section 6.5), the safer conclusion is the negative one: in neither curriculum does the demand on students' reasoning increase from Grade 7 to Grade 9.

Ghana front-loads modelling, pattern description and translation into JHS 1, consistent with learning-progression research that places generalisation before symbolisation (Sun et al., 2023), but the thread does not continue into JHS 2 and 3, where execution takes over; with the independent coders' agreed codes, Ghana's high-demand statements disappear altogether by JHS 3. Classroom research shows why this matters: high-demand tasks tend to decline into routine procedures during enactment (Henningsen & Stein, 1997), and a curriculum whose high-demand statements thin out after the first year gives teachers little warrant to resist that decline. Systems that treat functional relationships as a continuous strand offer a contrast. Japan's lower secondary Course of Study carries functions through all three grades, from proportion and inverse proportion in Grade 7 to linear functions in Grade 8 and functions of the form $y = ax^2$ in Grade 9 (MEXT, 2017), and early algebra research likewise treats generalisation and functional thinking as an organising thread rather than an introductory topic (Blanton et al., 2015; Cai & Knuth, 2011; Kieran, 2004). For curriculum designers in any system, the implication is that progression

should be specified, and audited, on two axes: the complexity of the content and the reasoning students are asked to do with it.

7.3 Two routes to one examination

The central finding is that the curricula differ in which algebra they specify, and that these differences map directly onto the WASSCE syllabus. Ghana follows a route of breadth and relationships. It specifies patterns, functions and mappings; substitution into expressions and formulae; change of subject; and gradient and intercept, all of which prepare students for WASSCE topics on formulae, functions and graphs. It does not specify algebraic methods for simultaneous equations, factorisation of quadratic expressions or the difference of two squares, or equations with fractions; these are prerequisites for WASSCE simultaneous-equation questions and for solving quadratic equations by factorisation, which, on the evidence of the intended curriculum, Ghanaian senior high schools must introduce. Nigeria follows a route of procedural depth. It specifies factorisation in all four WASSCE forms, elimination and substitution methods, equations with fractions, and algebraic fractions with monomial denominators, but not patterns and relations, substitution, change of subject, gradient or functions. Nigerian senior secondary schools therefore inherit a strong toolkit for quadratic equations but must build functional thinking, formula manipulation and graph interpretation largely from scratch. Research on functional thinking suggests this is not a minor omission (Utami et al., 2023).

In neither case does specification guarantee learning. Ghanaian JHS learners make frequent comprehension and transformation errors on algebraic word problems (Baidoo, 2025; Kenney & Ntow, 2024), and Nigerian secondary students struggle to form simultaneous and quadratic equations from word problems (Ogbu, 2025), although these topics are among Nigeria's most fully specified. The intended-curriculum differences reported here are therefore best read as differences in opportunity to learn, which enacted teaching may widen or narrow. Such differences matter beyond the two countries: international analyses show that exposure to formal mathematics content is strongly related to performance, and that unequal exposure between and within systems contributes to unequal outcomes (Schmidt et al., 2015). When two national curricula supply different subsets of the prerequisites assumed by one examination, the examination becomes the point at which curricular differences turn into differences in attainment, and those differences may widen further as curricula are translated into textbooks (Valverde et al., 2002; Wijaya et al., 2015).

7.4 One examination, several curricula

A common examination presupposes a common foundation. The WAEC syllabus directs teachers to their national curricula and limits country-specific content to two Section B questions (WAEC, n.d.), yet its algebraic-process content assumes junior secondary preparation that neither country provides fully and that each provides differently. Comparisons of Core Mathematics outcomes across member states therefore need to account for the different junior secondary routes by which candidates reach the same syllabus, as well as for differences in reporting conventions (Section 2). The policy implication is coordination of prerequisites, not uniformity: a regional reference framework of junior secondary algebra

prerequisites for the WASSCE would allow each country to keep its own organisation (a spiral in Ghana, topic blocks in Nigeria) while making visible what each senior secondary system must supply. Nigeria's 2025/26 curriculum revision (Voice of Nigeria, 2025) and Ghana's new senior high school mathematics curriculum (NaCCA, 2023) offer immediate opportunities to use such a framework.

The Ghana–Nigeria case is one instance of a wider arrangement in which a single examination sits above several national curricula. The Caribbean Secondary Education Certificate (CSEC) Mathematics examination is taken across Caribbean territories that set their own lower secondary curricula, with a regional pass rate of 42% in 2026 (Small, 2026); East African Community partner states have drafted harmonised secondary curriculum frameworks (Kenya Institute of Curriculum Development [KICD], n.d.); and international qualifications such as the Cambridge IGCSE are taken in systems whose lower secondary curricula vary widely. The same question applies in each setting: what does the common examination assume, and which of those assumptions does each feeding curriculum provide? The method used here transfers directly. Shared examinations also concentrate influence. Public examinations strongly shape what is taught in African systems (Kellaghan & Greaney, 2004), and high-stakes tests narrow curricular content and push pedagogy toward fragmented, teacher-centred instruction (Au, 2007). If the WASSCE largely rewards lower-order performance, raising the demand of national curricula alone is unlikely to change classroom practice; a deliberate shift in item design toward justification, generalisation and modelling, which international frameworks place at the centre of mathematical literacy (OECD, 2023), would send one signal to several national systems at once.

7.5 Raising demand without overloading the curriculum

How the gaps are closed matters. Curricula in many low- and middle-income countries move faster than students learn, and this overambition can lower achievement (Pritchett & Beatty, 2015); curriculum overload, in which added content crowds out depth, is a common problem across systems (OECD, 2020) and motivated Nigeria's recent revision. The implication of the present findings is therefore not that each country should add the other's missing topics. A more defensible response is to strengthen a small number of connected threads, such as functions and relations, equivalence and transformation of expressions, and modelling, across all three grades, and to raise the reasoning demanded within them rather than lengthen topic lists. This is consistent with the argument that coherence matters more than coverage (Schmidt et al., 2005) and with evidence that policies extending algebra to all students succeed only when they attend to the quality of the tasks students meet (Stein et al., 2011).

8. Conclusion

Ghana and Nigeria send their students to the same WASSCE by different junior secondary routes. Their intended algebra curricula are alike in cognitive demand: both sit at the Remember–Apply level, neither reaches higher-order processes or doing mathematics, and neither raises task demand across Grades 7–9, so apparent progression reflects accumulating procedures rather than deeper reasoning. Where the curricula differ is content. Ghana's breadth of relationships and formulae and Nigeria's depth of factorisation and equation solving each cover part of the algebraic foundation the WASSCE assumes,

but leave a different remainder for senior high school. Beyond the region, wherever several curricula feed one examination, alignment can be achieved at a low level of demand, apparent progression can be procedural accumulation, and differences in content can become differences in what later stages of schooling must supply; each of these possibilities can be checked with published documents before classroom data are collected.

Implications. For curriculum developers (NaCCA and NERDC), the findings support explicit higher-order statements at every grade (justifying steps, generalising patterns, comparing methods); in Ghana, extending the equation thread beyond x + a = b and adding algebraic methods for simultaneous equations; and in Nigeria, adding patterns, functions, substitution and change of subject. For WAEC and other regional examining bodies, such as the Caribbean Examinations Council, they support publishing the lower secondary prerequisites that each syllabus assumes and guaranteeing a share of items that require justification, generalisation and modelling. For senior high schools, they suggest diagnosing incoming students against the WASSCE prerequisites their junior curriculum omits. For researchers, they show the value of reporting demand with at least two frameworks, since a single hierarchy can mistake procedural accumulation for progression, and of using shared examinations as natural sites for comparing how different intended curricula translate into attainment.

Limitations. The study examined only the intended curriculum; enacted and attained curricula may differ. The Nigerian corpus was the Algebraic Processes theme, so related content, such as change of subject, may appear elsewhere in the full NERDC document, and Nigeria's revised curricula may change the picture for later cohorts. The 78 statements are a census of modest size, so non-significant results do not establish equivalence. The MTF was applied to curriculum statements rather than tasks, and indicates potential rather than enacted demand. The two independent coders agreed substantially with each other but applied a stricter threshold for procedures with connections than the decision rules, so the share of high-demand statements and the rise in RBT level across grades depend on how that boundary is drawn; the shared ceiling, on which all three codings agreed for every statement, does not. A consensus review of the boundary statements by all three coders would sharpen the task-demand estimates. The WASSCE coverage scores were assigned by one coder, although under explicit rules. Only algebra was analysed; related WASSCE content in the Number strand, such as variation and indices, was outside scope. Future work should analyse textbooks and classroom tasks in both countries, compare item-level WASSCE algebra performance of Ghanaian and Nigerian candidates, and extend the design to Sierra Leone, Liberia and The Gambia and to other multi-country examination settings.

Declarations

Declaration of Originality

The authors declare that this manuscript is an original work that has not been published previously and is not under consideration for publication elsewhere. All sources have been appropriately acknowledged and cited.

Conflict of Interest

The authors declare that they have no conflicts of interest regarding the publication of this manuscript.

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Author Contribution

G. A. M. was solely responsible for the conceptualisation, methodology, data collection, analysis, interpretation of findings, and writing and revision of the manuscript.

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Data Availability

All curriculum documents analysed in this study are publicly available from the issuing authorities: the National Council for Curriculum and Assessment (NaCCA), Ghana, and the Nigerian Educational Research and Development Council (NERDC). Each is cited in the reference list. The full coding scheme and the coded indicator data for all 78 statements are deposited at Zenodo: https://doi.org/10.5281/zenodo.23570844.

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Figures

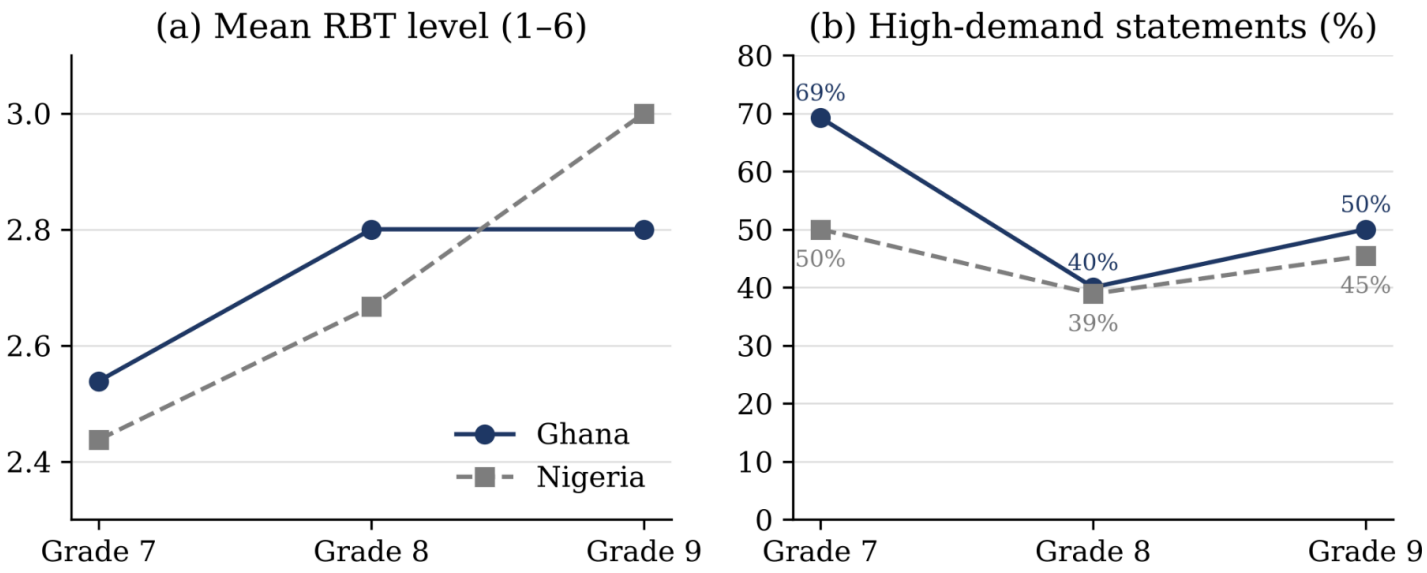

Figure 1

Mean RBT level (a) and share of high-demand statements (b) by grade and country. Source: rule-based codes for NaCCA (2020) and NERDC (2013) algebra statements; n = 78.