



Intended, Taught, and Tested: A Curriculum Alignment Analysis of the Mathematical Modelling Component of Nigeria's Further Mathematics Curriculum

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Abstract. Curriculum reform can fail not because any single component is broken, but because the intended curriculum, the taught curriculum, and the tested curriculum drift out of alignment with one another. This paper applies curriculum alignment theory (Cohen, 1987; Porter, 2002) to the Mathematical Modelling component introduced into Nigeria's Further Mathematics Curriculum (FMC) in 2011, mapping all 17 prescribed topics across Senior Secondary I-III against two independent data sources: a documentary content analysis of the Further Mathematics textbooks in use, and a proforma analysis of West African Examinations Council (WAEC) and National Examination Council (NECO) papers for 2014 and 2015. Findings show reasonable alignment between the intended and taught curriculum, with textbooks adequately treating 13 of the 17 prescribed topics (76.5%), but almost total misalignment between the intended/taught curriculum and the tested curriculum: across four examination administrations (WAEC 2014, WAEC 2015, NECO 2014, NECO 2015), only one, NECO 2015, included any Mathematical Modelling items at all, amounting to three items in total. Drawing on washback theory (Alderson & Wall, 1993), the paper argues that this near-total absence of examination alignment removes the principal external incentive that typically sustains attention to new curriculum content in Nigerian secondary schools, regardless of how well that content is otherwise resourced or textbook-supported. The paper recommends coordinated action between curriculum developers and examination bodies as a precondition for durable implementation of newly introduced mathematics content, both for the Mathematical Modelling component specifically and for Nigeria's 2025 NERDC curriculum reform more broadly.

Keywords: Curriculum alignment, washback, Mathematical Modelling, Further Mathematics Curriculum, Examination Bodies.

1. Introduction

Curriculum reform is often evaluated as though it had a single point of failure: either the new content is written into the syllabus and reform succeeds, or it is not and reform fails. Curriculum alignment theory offers a more precise diagnostic. Cohen (1987) distinguished between the intended curriculum, what policy documents specify should be taught, the taught or enacted curriculum, what is actually delivered in classrooms and embodied in the instructional materials teachers use, and the tested or assessed curriculum, what external examinations actually measure. Instructional alignment theory holds that the closer these three curricula track one another, the larger the effect of instruction on measured learning; where they diverge, instructional effort and assessment outcomes decouple from one another, undermining reform regardless of how well any single curriculum is designed (Cohen, 1987; Porter, 2002).

This paper applies that three-way alignment lens to a specific case: the Mathematical Modelling component introduced into Nigeria's Further Mathematics Curriculum (FMC) in 2011. Two companion analyses have already examined this reform from other angles, one treating textbook and material availability as implementation infrastructure, another examining teacher-level training needs. This paper asks a different, more structural question: independent of resourcing and teacher capacity, how well did the intended curriculum (the 17 Mathematical Modelling topics specified in the FMC), the taught curriculum (as embodied in the textbooks teachers actually used), and the tested curriculum (as embodied in WAEC and NECO examination papers) align with one another? Where alignment breaks down, curriculum alignment theory predicts that reform intent will not reliably translate into classroom priority, however well the content is otherwise supported.

1.1 Statement of the Problem

No prior study had mapped the Mathematical Modelling component of the FMC across all three levels of curriculum alignment, intended, taught, and tested, for the same set of prescribed topics. Without this mapping, it is not possible to determine whether implementation shortfalls in this component stem from a genuine curriculum-to-textbook gap, a curriculum-to-assessment gap, or both, each of which implies a different remedy. This study addressed that gap by constructing a topic-level alignment analysis of all 17 Mathematical Modelling topics prescribed in the FMC against textbook treatment and WAEC/NECO examination coverage.

2. Literature Review

2.1 Instructional Alignment Theory

Cohen (1987) argued that when the stimulus conditions of instruction, curriculum, and assessment are closely matched, the resulting effect on measured achievement is substantially larger than that produced by most other instructional interventions. Porter (2002) operationalized this insight into tools for measuring the content of instruction, instructional materials, and assessments as content maps, allowing researchers to compare what standards specify, what textbooks cover, and what tests measure on a common scale. Both traditions converge on a central claim relevant here: curriculum documents alone do not determine what is taught or what is learned; alignment across the intended, taught, and tested curriculum does.

2.2 Washback and the Role of External Examinations

In education systems where external, high-stakes examinations dominate the credentialing pathway, as is the case with WAEC and NECO in Nigerian secondary education, the tested curriculum exerts a particularly strong influence on classroom priority, a phenomenon Alderson and Wall (1993) termed washback: the extent to which a test's content and format shape what and how teachers teach, independent of curriculum documents. Where washback is positive, examinations reinforce curriculum intent; where a reform component is essentially untested, washback theory predicts that teachers and schools, operating under real time and resource constraints, will rationally deprioritize it relative to examinable content, whatever the curriculum document says should be taught.

3. Methodology

3.1 Research Design and Sample

The study used a descriptive, documentary content-analysis design. Two independent data sources were analyzed against the intended curriculum, defined as the 17 Mathematical Modelling topics prescribed across SSS I-III in the FMC. The taught curriculum was operationalized through a structured teacher-rated instrument (Mathematical Modeling Evaluation Questionnaire II, MMEQ II) assessing the extent to which Further Mathematics textbooks in use treated each of the 17 topics, completed by the 40 sampled Further Mathematics teachers drawn from 26 public and private senior secondary schools in Edo South Senatorial District. The tested curriculum was operationalized through a proforma content analysis of WAEC and NECO Further Mathematics examination papers for the 2014 and 2015 examination cycles, the first two cycles administered after the reform's introduction, recording the number of objective and theory items addressing Mathematical Modelling content in each administration.

3.2 Instrument, Validity, and Reliability

MMEQ II used a four-point Likert-type response format, with a scale midpoint of 2.5 as the decision threshold for adequacy: mean scores at or above 2.5 were classified as adequately treated, and scores below 2.5 as not adequately treated. The instrument was content-validated by measurement and evaluation specialist, and piloted with Further Mathematics teachers in three non-sampled schools, yielding a Cronbach's alpha of 0.714 for the textbook-adequacy subscale, (Omorogiuwa, 2006).

3.3 Method of Data Analysis

Descriptive statistics (means and standard deviations against the 2.5 threshold) were used to classify each of the 17 topics as adequately or not adequately treated by textbooks. WAEC/NECO proforma data were analyzed as frequency counts of objective and theory items per examination administration. An overall alignment index was then computed for each curriculum pairing: the proportion of topics adequately treated by textbooks (intended-taught alignment), and the proportion of examination administrations containing any Mathematical Modelling item (taught/intended-tested alignment).

4. Results

4.1 Intended-Taught Alignment: Topic-Level Textbook Coverage

Table 1 maps all 17 Mathematical Modelling topics prescribed in the FMC against their treatment in the Further Mathematics textbooks in use.

Table 1: Curriculum-Textbook Alignment Matrix for the 17 Mathematical Modelling Topics (N = 40 teacher raters)

Class Level	Topic	Mean	Textbook-Adequate?
SSS I	Definition of Operations Research	2.68	Yes
SSS I	History and Nature of Operations Research	2.40	No
SSS I	Models of Operations Research	2.38	No
SSS I	Practical Application of Models	2.27	No
SSS II	Concept of Inventory	2.72	Yes
SSS II	Definition of Terms (holding, demand, ordering, EOQ)	2.60	Yes
SSS II	Concept of Replacement	2.53	Yes
SSS II	Individual Replacement of Sudden Failure Items	2.50	Yes
SSS II	Replacement of Items that Wear Off Gradually	2.37	No
SSS III	Dependent and Independent Variables	2.75	Yes
SSS III	Construction of Models	2.61	Yes
SSS III	Methodology of Modelling	2.60	Yes
SSS III	Application of Modelling	2.60	Yes
SSS III	Introduction to Games Theory	2.57	Yes
SSS III	Description of Types of Games	2.61	Yes
SSS III	Solution of Two-Person Zero-Sum Games	2.52	Yes
SSS III	Matrix Games	2.68	Yes

Of the 17 prescribed topics, 13 (76.5%) were adequately treated by the textbooks in use, and 4 (23.5%) were not. The four gaps clustered at two points: the SSS I foundational topics (History and Nature of Operations Research; Models of Operations Research; Practical Application of Models), where three of four topics fell short, and a single SSS II topic (Replacement of Items that Wear Off Gradually). By SSS III, all eight topics, covering Model Construction and Games Theory, the most applied content in the component, were adequately treated. On this measure, intended-taught alignment for Mathematical Modelling was moderately strong overall, but weakest exactly where students first encounter the component.

4.2 Taught/Intended-Tested Alignment: Examination Coverage

Table 2 reports Mathematical Modelling item counts across the four examination administrations available in the two years immediately following the reform's introduction.

Table 2: Examination Alignment Index for Mathematical Modelling, 2014-2015

Examination Administration	Objective Items	Theory Items	Any MM Content?
WAEC 2014	0	0	No
WAEC 2015	0	0	No
NECO 2014	0	0	No
NECO 2015	2	1 (parts a & b)	Yes

Of the four examination administrations analyzed, only one, NECO 2015, contained any Mathematical Modelling content at all, an alignment rate of 25%. In total, three items across two years and two

examination bodies addressed a curriculum component spanning 17 distinct topics across three class levels. WAEC, the examination body used by the larger share of Nigerian secondary school

candidates, tested the component in neither year examined.

5. Discussion

Reading through Cohen's (1987) and Porter's (2002) alignment framework, these findings locate the Mathematical Modelling reform's principal structural weakness precisely: not in the intended-taught relationship, where alignment was reasonably strong at 76.5%, but in the relationship between the intended/taught curriculum and the tested curriculum, where alignment was close to zero. This distinction matters for remedy. A textbook-adequacy gap is addressed by revising textbooks; an examination-alignment gap can only be addressed by the examination bodies themselves changing what they test, a lever entirely outside the control of curriculum developers, textbook authors, or classroom teachers.

Washback theory (Alderson & Wall, 1993) explains why the examination gap is likely to matter more than its small item count might suggest. In examination-driven systems such as Nigeria's, teachers and school administrators face strong incentives to allocate instructional time toward examinable content. A component that is well-treated in textbooks but tested in only one of four examination administrations, and never by WAEC, sends a clear signal about relative priority, regardless of what the curriculum document intends. This may help explain why teacher training-need findings reported elsewhere in this evaluation program showed persistently low self-rated competence in the more applied Mathematical Modelling strands: without examination pressure reinforcing these topics, neither teachers nor schools have a strong external incentive to invest scarce professional development time in them, even where textbook support exists. This interpretation extends beyond what the present documentary data can directly confirm, since classroom-level instructional time was not observed directly, and should be read as a plausible mechanism rather than a directly measured effect.

The pattern also has clear implications for Nigeria's 2025 NERDC curriculum reform (NERDC, 2025). Any newly introduced content area that follows the same trajectory, reasonable textbook alignment but negligible examination alignment, is, on this evidence, likely to remain under-prioritized in classrooms regardless of how well it is otherwise resourced. Coordinating curriculum revision with examination body assessment blueprints from the outset, rather than treating examination alignment as a downstream concern, is therefore a structural precondition for reform durability, not merely a desirable add-on.

6. Recommendations

Based on these findings, the following recommendations are offered:

- WAEC and NECO should be formally engaged during curriculum development, not after curriculum launch, so that examination blueprints are updated to reflect new content areas from the first examination cycle following a reform, rather than years afterward.
- The Mathematical Association of Nigeria (MAN) should monitor and publicly report examination-alignment indices, of the kind constructed in this study, for newly introduced mathematics curriculum content, providing an early warning indicator of washback risk independent of resourcing indicators.
- Textbook authors and NERDC curriculum reviewers should prioritize revision of the SSS I foundational topics identified here as the weakest point of textbook alignment, since foundational gaps are likely to compound across the three-year sequence.
- Curriculum planners overseeing the 2025 NERDC reform should build a formal intended-taught-tested alignment audit, of the kind demonstrated in this study, into the standard curriculum evaluation cycle for all newly introduced content areas.

7. Conclusion

Applying curriculum alignment theory to the Mathematical Modelling component of the Further Mathematics Curriculum reveals a reform that succeeded reasonably well at aligning intended content with textbook treatment, but failed almost entirely to align either with what external examinations actually tested. Because Nigerian secondary education operates within an examination-driven system, this tested-curriculum gap represents the most consequential structural weakness identified across this evaluation program, one that textbook revision or teacher training alone cannot resolve. As Nigeria implements its 2025 NERDC curriculum reform which extends to other countries, treating examination alignment as a first-order design requirement, rather than a downstream implementation detail, is likely to matter more for reform durability than any other single factor examined in this analysis.

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