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Psychometric Evaluation of the Music Model of Motivation in Mathematics: A Case of Secondary School Students in Nigeria

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Abstract

Mathematics underachievement remains a persistent problem in Nigerian secondary education. While motivation is widely recognised as a contributing factor, existing Nigerian research has relied on generic motivation scales that cannot identify which specific classroom strategies teachers should target. This study addresses that gap by conducting a psychometric evaluation of the MUSIC model of mathematics motivation among randomly selected 248 secondary school students in Kaduna State, Nigeria. Confirmatory factor analysis was used to test the hypothesised five-factor structure (empowerment, usefulness, success, interest, and caring), first as separate single-factor models and then as a combined, correlated five-factor model, using the WLSMV estimator. Then, McDonald's omega was used to estimate the reliability coefficient. Results showed that empowerment, success and caring dimensions demonstrated an excellent model fit of the single factor structure with generated dataset. For each of the usefulness and interest dimensions, the model was saturated with appropriate local fit indices. The combined five-factor model achieved acceptable, though not excellent, global fit (CFI = .949, TLI = .938, RMSEA = .070, SRMR = .048), but revealed markedly high correlations among interest, success, and usefulness (up to .94), raising discriminant validity concerns. Reliability was strong for the scale overall (ω = .872) but fell below the .70 threshold for empowerment (ω = .684) and interest (ω = .639) individually. These findings indicate that the MUSIC–M can be used with reasonable confidence to measure students' motivation in mathematics.

Keywords: MUSIC model of motivation, confirmatory factor analysis, psychometric validation, mathematics motivation, Nigerian secondary education

1 Introduction

Mathematics occupies a foundational position in secondary education because it develops quantitative reasoning and supports progression into science, technology, engineering, and other fields requiring mathematical competence. Nevertheless, mathematics learning remains challenging for many students, making the investigation of factors that shape their engagement and achievement an enduring concern for mathematics education (Anietimfon et al., 2026; Ginga & Zakariya, 2020). Among these factors, motivation is particularly important because it influences students' willingness to initiate, sustain, and invest effort in learning activities. Evidence from Nigeria indicates that students' motivation is associated with differences in mathematics achievement (Tella, 2007). However, establishing an association between motivation and achievement is not equivalent to establishing that the instrument used to measure motivation adequately represents the construct. Consequently, strengthening mathematics education research requires not only investigating motivational influences but also ensuring that the instruments used to operationalise motivation possess appropriate psychometric properties for their intended populations.

The MUSIC Model of Academic Motivation provides a potentially useful framework for this purpose. Developed by Jones (2009, 2018), the model organises motivational instructional strategies into five interrelated dimensions: empowerment, usefulness, success, interest, and caring. Empowerment concerns students' perceptions of having meaningful control or choice in their learning; usefulness reflects their perceptions that learning contributes to present or future goals; success concerns their expectations of being able to accomplish learning tasks; interest captures their perceptions of the appeal of learning activities; and caring refers to their perceptions that teachers and others in the learning environment value their learning and wellbeing. Rather than proposing an entirely independent theory of human

motivation, the MUSIC model synthesises principles from established motivational perspectives into a practical framework for understanding and improving instructional environments (Jones, 2009, 2018; Jones et al., 2025).

The model offers a theoretically coherent basis for examining mathematics motivation because it directs attention beyond students' general willingness to learn towards specific perceptions that teachers may influence through instructional decisions. For example, opportunities to select problem-solving approaches may support empowerment, real-life mathematical applications may strengthen perceived usefulness, appropriately scaffolded tasks may enhance expectations of success, intellectually stimulating activities may foster interest, and constructive teacher–student relationships may communicate caring. These dimensions provide complementary perspectives on students' experiences of mathematics instruction. Importantly, however, the model does not imply that any single dimension independently determines achievement or that the five dimensions necessarily operate identically across educational settings.

Recent evidence supports the model's research potential while underscoring the importance of distinguishing motivational outcomes. In a systematic review and meta-analysis of 105 publications, Jones et al. (2025) found that MUSIC perceptions were moderately to strongly associated with student engagement, domain identification, and course evaluations, whereas their associations with academic achievement were comparatively weaker. This distinction suggests that the model may be particularly informative for understanding students' perceptions of the motivational climate rather than treating motivation as a direct or sufficient explanation of academic performance. Moreover, the review identified 20 publications involving validation of MUSIC-related inventory scales, demonstrating that establishing measurement quality is an important component of the model's research application. Empirical studies further illustrate the model's application across disciplines and national contexts. Jones et al. (2019), for example, evaluated the short-form MUSIC Inventory among 578 veterinary medicine students and reported evidence supporting its psychometric suitability in that population. In computer programming education, Alshammari (2023) examined relationships between the five MUSIC components and achievement among 97 participants, identifying usefulness, caring, and interest as significant predictors of learning success. In China, Li et al. (2022) investigated students' perceptions of motivational climate in university English courses and examined their relationships with engagement and achievement. Collectively, these studies demonstrate the model's applicability beyond its original disciplinary setting. Nevertheless, evidence that an instrument performs satisfactorily in one population does not establish that its measurement structure will remain appropriate in another.

This qualification is central to the present study. Psychometric properties belong to the interpretation and use of scores in particular populations and contexts; they should not be assumed to transfer automatically across educational levels, languages, subjects, or cultural environments. The 2025 systematic review identified applications across educational levels and national settings, but the existence of international applications does not eliminate the need for context-specific evaluation (Jones et al., 2025). In particular, the factor structure and reliability of an adapted MUSIC instrument require empirical examination before its scores can be interpreted confidently as indicators of mathematics motivation among Nigerian secondary school students. The Nigerian context makes this investigation worthwhile. Tella's (2007) study established an empirical basis for examining motivation and mathematics achievement among Nigerian secondary school students using a general academic motivation measure. However, that study did not evaluate the five-dimensional MUSIC framework. Thus, evidence concerning the relevance of motivation to Nigerian mathematics education does not, by itself, establish whether empowerment, usefulness, success, interest, and caring can be measured reliably and distinguished empirically within this population. Furthermore, findings from studies involving university students in veterinary medicine, computer programming, and English language learning cannot substitute for direct psychometric evidence from secondary mathematics classrooms (Alshammari, 2023; Jones et al., 2019; Li et al., 2022).

The resulting research gap is both methodological and contextual. Methodologically, the adaptation of an established motivational inventory requires evidence that its items represent the intended latent construct and that the proposed measurement model adequately describes observed responses. Contextually, the suitability of the five-dimensional structure remains an empirical question when the instrument is applied to Nigerian secondary school students learning mathematics. Without such evidence, researchers risk interpreting scores using an assumed structure, while teachers and educational stakeholders may draw instructional conclusions from measurements whose precision has not been adequately established. Conversely, a satisfactory psychometric evaluation would provide a stronger foundation for subsequent investigations of mathematics motivation and its relationship with engagement and achievement. Accordingly, this study evaluates the psychometric properties of the adapted MUSIC Model of Motivation scale (MUSIC–M) among Nigerian secondary school students learning mathematics. Specifically, it examines the adequacy of

the hypothesised measurement model, investigates the factor loadings of the items on the underlying construct or dimensions, and estimates the scale's reliability. The study is guided by the following research questions:

1. Does the hypothesised measurement model of the adapted MUSIC–M adequately fit the observed data?
2. What are the factor loadings of the MUSIC–M items on their hypothesised latent dimension or dimensions?
3. What is the reliability coefficient of the adapted MUSIC–M?

By addressing these questions, the study seeks to establish context-relevant evidence for interpreting MUSIC–M scores in Nigerian secondary mathematics education. Its contribution lies not in presuming that the MUSIC model is universally transferable, but in examining whether its proposed measurement structure is empirically defensible in the population under investigation. The findings may consequently inform future research on mathematics motivation and provide a foundation for more evidence-informed investigations of classroom motivational conditions in Nigeria.

2 Materials and Methods

2.1 Research Design

This study adopted a quantitative, cross-sectional survey design to evaluate the psychometric properties of the MUSIC Model of Motivation, adapted for mathematics (MUSIC–M), among secondary school students in Nigeria

2.2 Participants

The participants comprised 248 senior secondary school mathematics students with an average of 16 years selected through simple random sampling technique. The sample includes 125 females, 111 males and 12 students who didn't indicate their gender.

2.3 Measurement of Motivation

Students' motivation to learn mathematics was measured with the MUSIC–M, an adaptation of Jones's (2017) MUSIC Model of Academic Motivation Inventory (middle/high school version). The inventory is based on Jones's MUSIC model, which holds that motivation is shaped by students' perceptions of five components of the classroom environment: empowerment, usefulness, success, interest, and caring. The adapted scale has 18 items rated on a 6-point Likert scale, distributed across five subscales: empowerment (4 items: freedom, choice, and control over learning), usefulness (3 items: relevance of mathematics to the future), success (4 items: confidence in succeeding), interest (3 items: enjoyment and attention), and caring (4 items: teacher support, friendliness, and respect). The items were adapted by changing "science class" and "science teacher" to "mathematics class" and "mathematics teacher" in each original item, with no other changes (Table 1).

Table **1**

Item Distribution and Adaptation of the MUSIC Model of Motivation Inventory (MUSIC–M).

Dimension	**Original item Jones (2017)**	**Adapted mathematics-specific item (MUSIC–M)**
Empowerment	I have the freedom to complete my science class work in my own way.	I have the freedom to complete my mathematics class work in my own way.
Empowerment	I have choices in what I am allowed to do in science class.	I have choices in what I am allowed to do in mathematics class.
Empowerment	I have control over how I learn the content in science class.	I have control over how I learn the content in mathematics class.
Empowerment	I have options in how to achieve the goals in science class.	I have options in how to achieve the goals in mathematics class.
Usefulness	The knowledge I gain in science class is important for my future.	The knowledge I gain in mathematics class is important for my future.

Dimension	Original item Jones (2017)	Adapted mathematics-specific item (MUSIC–M)
Usefulness	In general, science class work is useful to me.	In general, mathematics class work is useful to me.
Usefulness	I find science class work to be relevant to my future.	I find mathematics class work to be relevant to my future.
Success	I am confident that I can succeed in science class work.	I am confident that I can succeed in mathematics class work.
Success	I am capable of getting a high grade in science class.	I am capable of getting a high grade in mathematics class.
Success	I feel that I can be successful in meeting the academic challenges in science class.	I feel that I can be successful in meeting the academic challenges in mathematics class.
Success	During science class, I feel that I can be successful on the class work.	During mathematics class, I feel that I can be successful on the class work.
Interest	The science class work is interesting to me.	The mathematics class work is interesting to me.
Interest	I enjoy completing science class work.	I enjoy completing mathematics class work.
Interest	The science class work holds my attention.	The mathematics class work holds my attention.
Caring	My science teacher cares about how well I do in science class.	My mathematics teacher cares about how well I do in mathematics class.
Caring	My science teacher is friendly.	My mathematics teacher is friendly.
Caring	My science teacher is willing to assist me if I need help in science class.	My mathematics teacher is willing to assist me if I need help in mathematics class.
Caring	My science teacher is respectful of me.	My mathematics teacher is respectful of me.

2.4 Data Collection and Analysis

Data were collected by administering the adapted MUSIC motivation scale (MUSIC–M) to secondary school students randomly selected in Zaria, Kaduna State, Nigeria. Before data collection, permission was obtained from the relevant authorities of the institution, including the school management. The purpose of the study was explained to the participants, and informed consent was obtained before administration. The participants were assured that participation was voluntary, their responses would be treated confidentially, and the information provided would be used solely for research purposes. The 248 secondary school mathematics students who consented to participate completed the questionnaires using a paper-and-pencil format, administered during regular mathematics class periods. The completed questionnaires were collected immediately, screened for completeness, coded, and entered into the statistical software for analysis.

The psychometric properties of the MUSIC–M were evaluated using Confirmatory Factor Analysis (CFA). A five-factor model comprising empowerment, usefulness, success, interest, and caring was hypothesised and evaluated using the Weighted Least Squares Mean and Variance Adjusted (WLSMV) estimator, given the ordinal categorical nature of the response options. Model fit was assessed using the Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardised Root Mean Square Residual (SRMR). Following Hu and Bentler (1999) and Brown (2015), CFI and TLI values of .90 or higher, and RMSEA and SRMR values below .08 were considered acceptable, while CFI and TLI values above .95 indicated excellent fit. Standardised factor loadings and residuals were also examined to assess local model fit. Finally, McDonald's omega (ω) was used to estimate the reliability of the MUSIC–M.

3 Results

3.1 Addressing Research Question 1

In order to evaluate the factor structure of the MUSIC-M model, we hypothesised a single-factor structure for each of the dimensions of the construct and investigated the global fit of the models. Table 2 presents the global fit statistics for each of these models.

Table **2**

Goodness of fit statistics for evaluated MUSIC- M model

Global fit statistics	**Empowerment**	**Usefulness**	**Success**	**Interest**	**Caring**
Chi-square					
Estimate (χ^2)	3.779	0.00	7.258	0.00	3.095
df	2	0	2	0	2
p-value	.1511	<.001	.0265	<.001	.2128
χ^2 / df					
RMSEA					
Estimate	.062	<.001	.106	<.001	.049
90% C.I.	[<.001, .157]	[.00, .00]	[.031, .194]	[.00, .00]	[<.001, .148]
Probability RMSEA <= .05	.312	0.00	.094	0.00	.390
CFI	.992	1.00	.993	1.00	.998
TLI	.975	1.00	.978	1.00	.995
SRMR	.013	<.001	.016	<.001	.011
Omega coefficient	**.684**	**.759**	**.824**	**.639**	**.842**

As shown in Table 2, the fit statistics varied across the five MUSIC–M subscales. The empowerment model demonstrated a non-significant chi-square (χ^2 = 3.779, *df* = 2, *p* = .151), excellent incremental fit indices (CFI = .992, TLI = .975), and acceptable approximation fit (RMSEA = .062, SRMR = .013), indicating that the single-factor structure of the empowerment subscale fit the observed data well. The success subscale presented a mixed picture: while the incremental fit indices were excellent (CFI = .993, TLI = .978) and SRMR was low (.016), the chi-square was statistically significant (χ^2 = 7.258, *df* = 2, *p* = .027) and RMSEA exceeded the conventional .08 threshold for acceptable fit (RMSEA = .106, 90% CI [.031, .194]). This divergence between the incremental indices and the absolute fit indices is not unusual in small-*df* models, where RMSEA can be unstable. Thus, the model demonstrates and excellent fit of the generated datasets. However, this result should be interpreted with caution.

The caring subscale showed the strongest and most consistent evidence of fit across all indices (χ^2 = 3.095, *df* = 2, *p* = .213; CFI = .998; TLI = .995; RMSEA = .049; SRMR = .011), indicating that its four-item single-factor structure reproduced the observed covariance structure closely. The usefulness and interest subscales, by contrast, returned perfect fit statistics (χ^2 = 0.00, CFI = 1.00, TLI = 1.00, RMSEA < .001) because each was specified with three items and zero degrees of freedom (*df* = 0). A three-indicator single-factor model is just-identified: it has exactly as many estimated parameters as observed data points, so the model reproduces the sample covariance matrix exactly regardless of whether the underlying construct is genuinely unidimensional. These fit statistics are therefore mathematically guaranteed rather than empirical evidence of good fit, and should not be interpreted as confirming the structure of these two subscales. As for the local fit statistics, Figure 1 presents the factor structure for each of the dimensions of the constructs including the factor loadings.

Figure **1**

Factor structure of the evaluated MUSIC model for each dimension of motivation

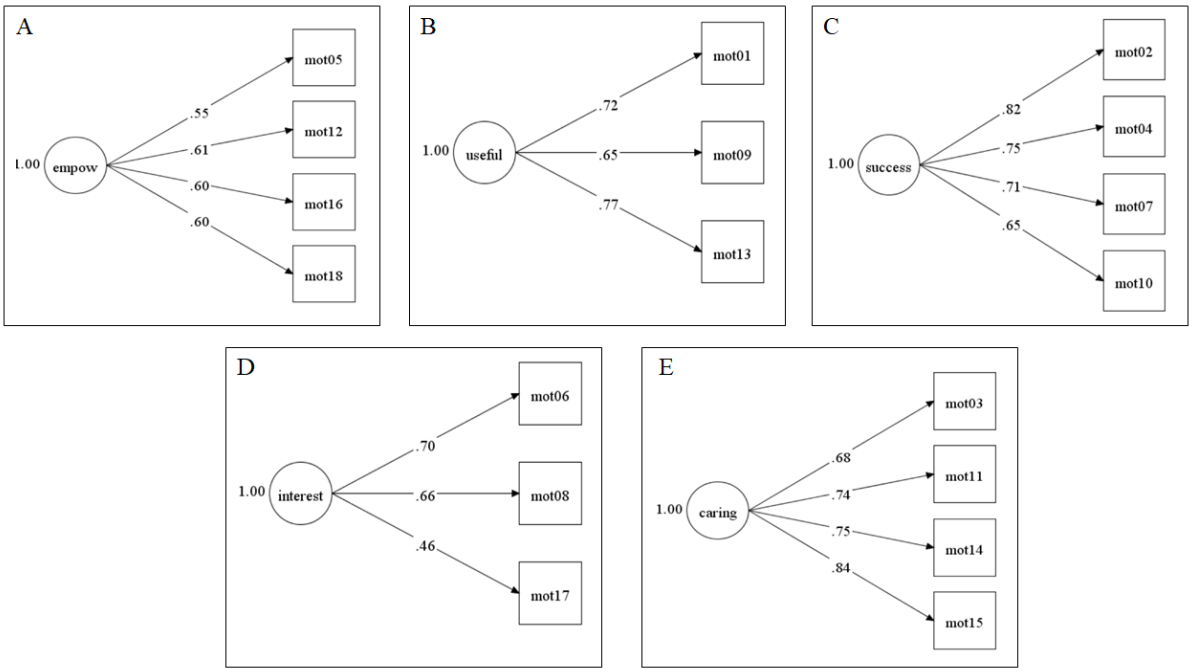


Figure 1 shows the standardized loadings underlying the presented models in Table 1. Loadings are generally healthy, ranging from roughly .55 to .84 across the five panels. Empowerment's four items load narrowly between .55 and .61 — fairly even but on the low side, which is consistent with its marginal Omega. Usefulness and Success show a healthier spread (.65–.77 and .65–.82, respectively). Interest (panel D) contains the one clear outlier in the whole set: mot17 loads at only .46, well below its sibling items (.66, .70) — a likely driver of Interest's low reliability (Ω = .639). Caring (panel E) shows the strongest and most consistent loadings of the five dimensions (.68–.84), matching its top Omega value.

3.2 Addressing Research Question 2

In order to evaluate the factor structure of the five-factor MUSIC-M model, we hypothesised the five-factor structure of all the dimensions of the construct and investigated the global fit of the model. Table 3 presents the global fit statistics for the model.

Table **3**

Goodness of fit statistics for evaluated MUSIC motivation models

Global fit statistics	**Estimate**
Chi-square	
Estimate (χ^2)	266.494
df	125
p-value	<.001
$\chi^2 \,/\, df$	
RMSEA	
Estimate	.070
90% C.I.	[.058, .081]
Probability RMSEA <= .05	.003

CFI	.949
TLI	.938
SRMR	.048

Table 3 showed that the combined five-factor model of MUSIC–M demonstrated an acceptable, though not excellent, fit with the observed data at the global level. The χ^2/df ratio was 2.13 (χ^2 = 266.494, *df* = 125), which falls within the more lenient threshold of 3 sometimes applied to larger models, though it exceeds the stricter threshold of 2. The model yielded an SRMR of .048, comfortably below the .08 threshold for acceptable fit. The RMSEA estimate was .070, with a 90% confidence interval of [.058, .081]; this falls within the conventional range for reasonable, though not close, approximation fit, and the confidence interval's upper bound marginally exceeds the .08 threshold, introducing some uncertainty about fit precision. Consistent with this, the probability of RMSEA ≤ .05 was low at .003, indicating that the hypothesis of close fit can be rejected, though this statistic is known to be sensitive to model complexity and sample size and is not, on its own, disqualifying. The CFI and TLI were .949 and .938, respectively — both exceeding the minimum acceptable threshold of .90, but falling just short of the .95 threshold that Hu and Bentler (1999) and Brown (2015) associate with excellent fit.

Collectively, these global fit statistics indicate that the correlated five-factor structure of the MUSIC–M with empowerment, usefulness, success, interest, and caring specified as distinct but related latent dimensions provided an acceptable fit to the data from secondary school mathematics students, though the fit fell short of the excellent-fit benchmarks achieved by some of the individual subscales reported in Table 1 (notably empowerment and caring). As for the local fit statistics, Figure 2 presents the five-factor structure of all the dimensions of the constructs including the factor loadings.

Figure **2**

Factor structure of the evaluated five-dimension MUSIC model for motivation

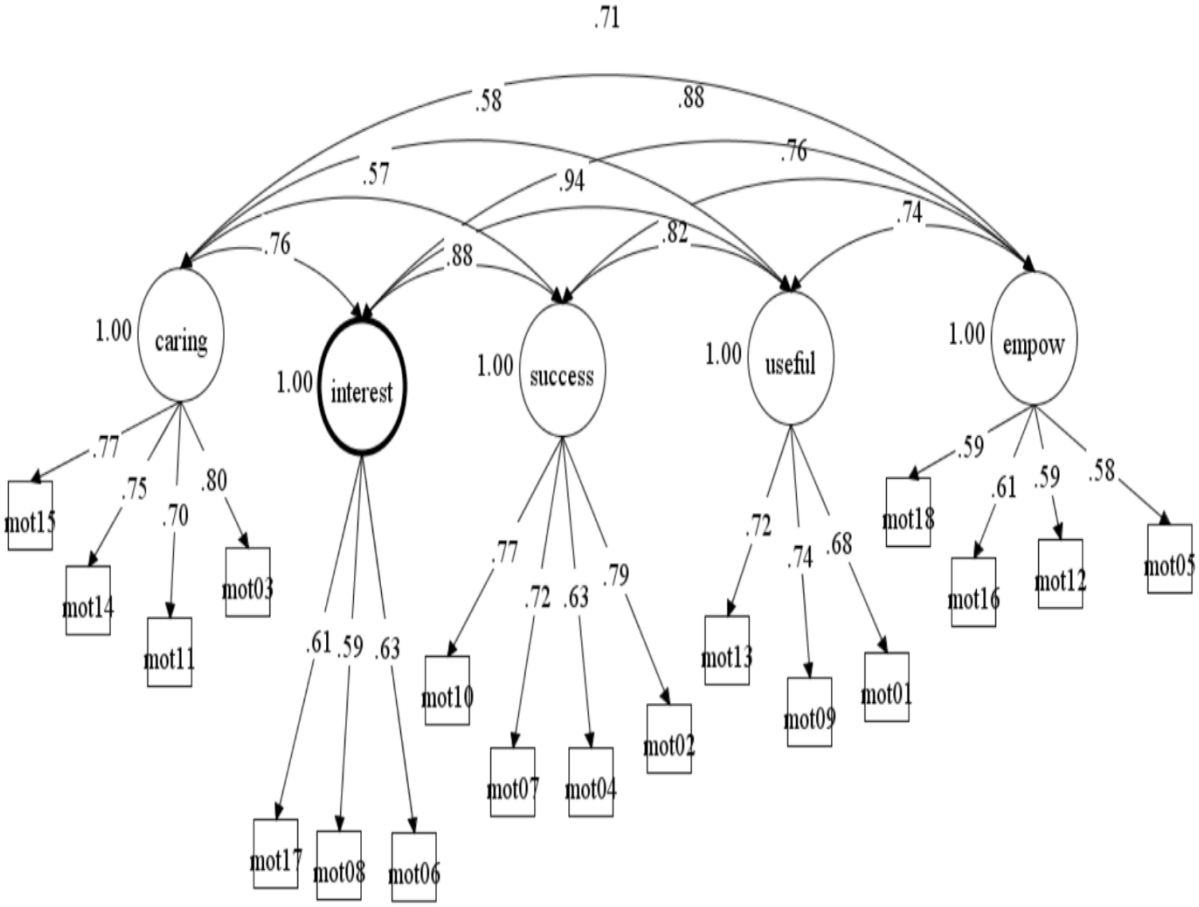


Figure 2 shows the full structural model with all five factors estimated jointly, including their correlations. Item loadings remain healthy throughout (roughly .58–.80), closely matching what was seen in Figure 1 — indicating the items behave stably whether modelled alone or together. One notable shift: mot17 (Interest), which loaded weakly (.46) in the separate model, rises to .61 here, likely because estimating it alongside correlated factors stabilizes the estimate. The key new information in Figure 2 is the set of correlations among the five latent factors, which single-factor models cannot reveal. Several of these are very high: Interest–Success (.94), Success–Usefulness (.88), Interest–Usefulness (.88), Success–Empowerment (.82), and Caring–Empowerment (.76). Correlations of this magnitude — several at or above .85 — raise a discriminant validity concern: it becomes statistically difficult to argue that Interest, Success, and Usefulness are fully distinct constructs rather than overlapping facets of a broader motivation factor.

3.3 Addressing Research Question 3

To address Research Question 3, McDonald's omega (ω) was computed for each subscale. The coefficients ranged from .639 (interest) to .842 (caring). Applying the commonly cited threshold of $\omega \geq .70$ for acceptable internal consistency, success ($\omega = .824$) and caring ($\omega = .842$) demonstrated good reliability, and usefulness ($\omega = .759$) demonstrated acceptable reliability. Empowerment ($\omega = .684$) and interest ($\omega = .639$) fell below this threshold, indicating weaker internal consistency for these two subscales (Zakariya, 2022). The reliability coefficient for the five-factor 18-item MUSIC motivation scale is .872 using coefficient Omega

4 Discussion

This study set out to determine whether the MUSIC Model of Academic Motivation developed and validated almost entirely with university-age respondents holds together empirically when adapted to mathematics and applied to a Nigerian secondary school population. The findings offer qualified rather than unqualified support, and in doing so both extend and complicate the consensus built up in the model's existing validation literature. At the level of individual subscales, empowerment and caring produced genuine, consistent evidence of good fit, while usefulness and interest could not be independently tested due to model saturation, and success showed a mixed pattern across fit indices. This partial replication is broadly consistent with the pattern reported in Jones, Ambarkutuk, and Schunk's (2025) systematic review and meta-analysis of 105 MUSIC-model publications, which found that MUSIC perceptions were moderately to strongly associated with engagement and course evaluations, but that the relationship with achievement itself was comparatively weaker — a distinction the authors attributed, in part, to variability in how cleanly the five constructs separate across samples. The present findings extend that caution to the structural level: it is not only the model's predictive relationships that vary in strength across contexts, but the underlying factor architecture itself.

The combined five-factor model's acceptable-but-not-excellent fit, and in particular the markedly high correlations among interest, success, and usefulness rising as high as .94 stand in some tension with the model's performance in the two populations closest to the present one in the existing literature. Jones, Byrnes, and Jones (2019) reported acceptable internal consistency and model fit for the MUSIC Inventory among veterinary medicine students, and Alshammari (2023) reported similarly acceptable psychometric behaviour among computer programming students. Both of these validations, however, were conducted with university students - a population that is older, more autonomous, and accustomed to a continuous-assessment culture very different from the WAEC- and JAMB-oriented examination culture that structures Nigerian secondary education. The present results suggest this age and schooling-culture gap may matter empirically, not just theoretically: where university students in veterinary medicine and computer programming apparently distinguish "the work is useful to me," "I can succeed at this work," and "I find this work interesting" as separable perceptions, the younger, more teacher-directed secondary students in this sample did so far less cleanly. This is consistent with a plausible developmental account already implicit in the introduction's framing that university students, who have more latitude to evaluate coursework on its personal relevance, may have had more opportunity to disentangle perceived usefulness from perceived competence and enjoyment than a fifteen-year-old JSS/SSS student whose engagement with mathematics is far more externally structured by teacher and curriculum.

The cross-cultural travel of the model is a closer comparator. Li, Jones, Williams, and Guo (2022) found that MUSIC perceptions predicted engagement and achievement among Chinese university students in English-language courses,

which was taken, in the introduction, as evidence that the framework is not strictly bound to the North American undergraduate contexts in which it originated. The present study's results neither straightforwardly confirm nor straightforwardly contradict that conclusion. Empowerment and caring arguably the two MUSIC dimensions most tied to concrete, observable classroom behaviour (having choices; an instructor's visible warmth) replicated well in this Nigerian secondary sample, suggesting that at least part of the model does travel across both the university-to-secondary and the North America-to-Nigeria boundaries simultaneously. But usefulness, success, and interest dimensions more bound up with the student's internal evaluation of the subject's relevance, their own competence, and their enjoyment of it showed the weakest discriminant separation. This pattern suggests the model's cross-cultural portability, demonstrated by Li et al. (2022) at the level of predictive relationships, does not automatically extend to portability of its internal factor structure once the model is also shifted down in age and across a subject domain, from language learning to mathematics.

This distinction matters for how the introduction's central claim that Nigerian mathematics education has no validated instrument capable of telling a teacher which lever to pull should now be qualified. Tella (2007) demonstrated, using a generic intrinsic/extrinsic motivation scale, that more highly motivated Nigerian secondary students significantly outperform less-motivated peers in mathematics achievement, but that scale was not designed to isolate which specific classroom strategy was responsible for the difference. The present results suggest the MUSIC–M can partially close that gap, but not uniformly across all five levers. A Nigerian mathematics teacher can, with reasonable empirical confidence, use this instrument to diagnose whether students feel they have choice and control over their learning (empowerment) or whether they feel cared for by their teacher (caring), since these two dimensions behaved as genuinely distinct, well-fitting constructs in this sample. Diagnosing whether a lack of motivation stems specifically from perceived irrelevance (usefulness), low confidence (success), or low enjoyment (interest), by contrast, should be done more cautiously, since this study's evidence suggests Nigerian secondary students may not experience these three dimensions as sharply distinct from one another.

Reliability findings add a further layer of nuance to this comparison with the prior literature. The overall 18-item MUSIC–M scale returned a strong omega of .872, comparable to or exceeding the acceptable internal consistency reported in the veterinary medicine (Jones, Byrnes, & Jones, 2019) and computer programming (Alshammari, 2023) validations. Yet two subscales — empowerment (ω = .684) and interest (ω = .639) — fell below the conventional .70 threshold when examined individually. Read alongside the high inter-factor correlations in the combined model, this suggests that the instrument's overall reliability is partly a function of item redundancy across constructs rather than uniformly strong internal consistency within each construct, a pattern that has not been prominently reported in the model's prior, university-based validations, and which may be specific to how a younger, more homogeneously-schooled population responds to these items.

Contextually, these findings are not merely a psychometric curiosity. The scale of mathematics underperformance documented at the outset of this study- the 2025 WASSCE recording the worst outcomes in a decade, with only 38.32% of candidates achieving the required credit pass, following a year in which over 500,000 students failed both English and Mathematics outright (BusinessDay NG, 2025; Sahara Reporters, 2024) is precisely the kind of outcome that motivation researchers, from Tella (2007) onward, have argued is bound up with classroom motivational climate. The present findings indicate that at least two of the five levers a Nigerian mathematics teacher might pull — empowerment and caring — can now be measured with reasonable psychometric confidence in this population, while the remaining three should be treated as a single, less-differentiated cluster of engagement-relevant perceptions until further validation work can establish whether they are genuinely separable constructs in Nigerian secondary classrooms.

Therefore, this study extends the MUSIC model's validation record into a population of Nigerian secondary mathematics students that sits outside the university-age, largely North American samples on which the model's existing psychometric consensus has been built (Jones, Byrnes, & Jones, 2019; Alshammari, 2023; Li et al., 2022), and it does so using a subject domain, mathematics, to which the inventory had not previously been adapted. In line with Hu and Bentler's (1999) and Brown's (2015) fit-index conventions applied throughout this analysis, the results indicate that the instrument travels unevenly: well for some dimensions, adequately for the model as a whole, and with meaningful discriminant ambiguity for others. This reinforces, rather than resolves, the broader point already established in the wider validation literature — that an instrument's structural validity cannot be assumed to hold constant across the age groups, schooling cultures, and disciplinary contexts into which it is adapted, and must instead be re-established empirically each time.

5 Conclusion

This study evaluated the psychometric properties of an adapted MUSIC Model of Motivation scale (MUSIC–M) among 250 secondary school mathematics students in Nigeria. The hypothesised five-factor structure, comprising empowerment, usefulness, success, interest, and caring, received only partial support. Empowerment and caring showed genuine, well-fitting single-factor structures, indicating that these two dimensions function as clear, measurable, and distinct aspects of classroom motivational climate for this population. Usefulness and interest could not be independently tested at the subscale level due to model saturation, and success showed a mixed pattern of fit depending on the index examined. When the five dimensions were estimated jointly, the combined model achieved acceptable, though not excellent, global fit. However, markedly high correlations emerged among interest, success, and usefulness, indicating that these three dimensions are not clearly distinguishable as separate constructs within this sample and instead appear to function more as overlapping facets of a broader motivational factor. Reliability findings reinforced this uneven picture. The scale as a whole demonstrated strong internal consistency, but two subscales, empowerment and interest, fell below the conventional threshold for acceptable reliability when examined on their own. This suggests that the overall reliability of the instrument is driven in part by the shared variance among its correlated dimensions rather than by uniformly strong internal consistency within each individual construct.

Overall, the findings indicate that the MUSIC–M can be used with reasonable confidence to measure empowerment and caring as distinct components of classroom motivational climate among Nigerian secondary mathematics students, while usefulness, success, and interest should, for now, be treated as a less clearly differentiated set of perceptions rather than three fully independent dimensions. Because the sample was drawn from a single school in one state, these findings are preliminary and should not be generalised to other regions, school types, or educational settings without further validation. Future research involving larger and more diverse samples, alternative factor specifications, and additional sources of validity evidence is needed to determine whether the observed structure is stable or specific to the population examined in this study.

6 Declarations

Ethical statements: All the participants gave individual written consent to participate in the research.

Conflict of Interest: The authors declare neither financial nor non-financial conflict of interest.

Author Contributions: PG, YFZ, REU, and SSM: Conceptualisation, Methodology, Supervision, Writing and Reviewing Original Draft. YFZ: Data Analysis. EVM and PG: Conceptualisation, Data Collection, Validation, Writing and Reviewing Original Draft. All authors approved the manuscript.

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Data Availability Statement: The dataset used for this study is available upon request from the corresponding authors.

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