Zero : Jurnal Sains, Matematika, dan Terapan
E-ISSN : 2580-5754; P-ISSN : 2580-569X
Volume 10, Number 2, 2026
DOI: 10.30829/zero.v10i2.29549
Page: 523-534

Psychometric Validation of a Multidimensional Learning Readiness Instrument Following Indonesia's Free Nutritious Meal Program

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Article Info

Article history:

Accepted: 10 July 2026

Keywords:

Confirmatory Factor Analysis;
Psychometric Validation;
Learning Readiness;
School Feeding Program;
Multidimensional Measurement;
MBG Program.

ABSTRACT

This study aimed to validate a multidimensional learning readiness instrument within the context of Indonesia's Free Nutritious Meal Program (MBG) using Confirmatory Factor Analysis (CFA). The instrument measured five dimensions: School Participation, Learning Concentration, Learning Energy, Psychological Readiness, and Academic Readiness. Data were collected from 366 students and analyzed using the Robust Maximum Likelihood estimator in R. One indicator (A3) was removed due to low factor loading, resulting in a revised 19-indicator measurement model. The final CFA model demonstrated acceptable goodness-of-fit indices (χ^2 = 294.356, df = 142, χ^2/df = 2.07, CFI = 0.944, TLI = 0.933, RMSEA = 0.054, SRMR = 0.042). Convergent validity, discriminant validity, and composite reliability generally supported the psychometric adequacy of the instrument. The findings suggest that the proposed instrument may serve as a useful multidimensional measurement tool for evaluating students' learning readiness within school feeding contexts.

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1. INTRODUCTION

Learning readiness is widely recognized as an important factor influencing students' academic engagement and learning performance. Students with higher readiness levels tend to demonstrate better concentration, stronger classroom participation, and greater preparedness in completing academic tasks [1], [2]. In educational psychology, learning readiness is commonly viewed as a multidimensional construct involving cognitive, behavioral, psychological, and physical dimensions that collectively support students' participation in learning activities [3], [4], [5].

In recent years, increasing attention has been directed toward the relationship between nutrition and educational outcomes. Adequate nutritional intake is associated with students' cognitive functioning, attention, emotional stability, and physical endurance during classroom learning [6], [7], [8]. Consequently, school feeding programs have been implemented in many countries to support both student health and educational participation [9], [10], [11]. In Indonesia, the government introduced the Free Nutritious Meal Program (MBG) as a national school feeding initiative implemented across educational settings in Indonesia [12].

Despite growing interest in school feeding programs, existing evaluation studies largely focus on single-dimensional outcomes such as nutritional status, attendance, or academic achievement [13]. Limited studies have developed multidimensional instruments specifically designed to assess students' learning readiness within school feeding contexts. In addition, several existing instruments have not been comprehensively evaluated using psychometric validation procedures such as Confirmatory Factor Analysis (CFA), particularly in the context of nutrition-based educational interventions [14].

Therefore, psychometric validation is necessary to ensure that multidimensional educational constructs are measured accurately and consistently [15]. Confirmatory Factor Analysis (CFA) provides a covariance structure modeling approach that enables researchers to evaluate construct validity, reliability, and the adequacy of latent measurement structures in educational assessment research [16]. In this context, the present study focuses on validating a multidimensional learning readiness instrument within Indonesia's Free Nutritious Meal Program (MBG).

This study does not propose a new theoretical framework but contributes through the contextual adaptation and psychometric validation of a multidimensional learning readiness instrument using CFA procedures. The proposed instrument evaluates five dimensions of learning readiness: School Participation, Learning Concentration, Learning Energy, Psychological Readiness, and Academic Readiness. The findings are expected to provide a psychometrically supported measurement tool for educational evaluation and future school feeding assessment research.

2. RESEARCH METHOD

This study employed a quantitative approach using an instrument development design to validate the construct of students' learning readiness in the context of Indonesia's Free Nutritious Meal Program (MBG). The primary objective was to evaluate the adequacy of the proposed measurement model and examine the psychometric properties of the instrument using Confirmatory Factor Analysis (CFA). The study focused on assessing construct validity, convergent validity, discriminant validity, and construct reliability of the multidimensional learning readiness instrument [17], [18].

2.1 Research Design

The study was conducted through several systematic stages. First, the theoretical dimensions of learning readiness were identified through an extensive review of educational psychology, learning readiness theory, and school feeding literature. Second, instrument items were generated based on the conceptual dimensions identified from the literature. Third, expert judgment procedures were conducted to evaluate the content validity and clarity of the instrument items. Fourth, a pilot test was administered to assess item readability and preliminary reliability. Finally, field data were collected and analyzed using Confirmatory Factor Analysis (CFA) to evaluate the construct validity and psychometric adequacy of the measurement model.

2.2 Population and Sample

The study population comprised students who had participated in the Free Nutritious Meal Program (MBG). The final sample consisted of 366 students, which met the recommended requirements for factor analysis and structural equation modeling. Previous methodological guidelines suggest that Confirmatory Factor Analysis (CFA) generally requires adequate sample sizes to ensure stable parameter estimation. The sample size of 366 was considered adequate because the final CFA model involved 19 observed indicators and approximately 53 free parameters, resulting in a sample-to-parameter ratio of about 6.9:1. In addition, the 19 observed variables produced 190 distinct sample moments, exceeding the number of free parameters and supporting model estimability. Thus, the sample size was sufficient for CFA estimation beyond the generic minimum sample rule or an estimated ratio of 5–10 respondents per measurement item to ensure stable parameter estimation and robust statistical analysis [19], [20].

Respondents were selected using proportional stratified sampling based on school representation and students' participation in the MBG program. Accessibility considerations were applied only during field implementation to facilitate data collection across participating schools while maintaining proportional representation among respondents. The present study focused primarily on psychometric validation of the overall measurement structure and did not include multi-group measurement invariance testing across demographic subgroups.

2.3 Measurement Instrument

The initial instrument consisted of 20 items measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The instrument was developed based on theories of learning readiness [21], educational psychology [3], and previous studies related to school feeding and educational evaluation [22]. The item development process aimed to capture the multidimensional nature of learning readiness, encompassing cognitive, psychological, behavioral, and physical dimensions associated with students' preparedness to engage in learning activities.

The instrument measured five latent constructs: participation, learning concentration, learning energy, psychological readiness, and academic readiness. Each construct was initially represented by four indicators in the proposed measurement model. The initial instrument consisted of 20 items. After CFA evaluation, one indicator (A3) was removed due to low standardized loading, resulting in a final 19-indicator measurement model. Several example items included: "I actively participate in classroom discussions" (participation), "I can maintain focus during lessons" (learning concentration), "I feel physically energized during learning activities" (learning energy), "I feel confident when participating in classroom activities" (psychological readiness), and "I am prepared to complete academic assignments" (academic readiness).

Prior to the main data collection, the instrument underwent expert validation involving three experts in educational evaluation and psychometrics, followed by pilot testing before the main survey administration.

A pilot test involving 30 students was also conducted before the main survey administration. The pilot study aimed to evaluate item readability, response clarity, and preliminary reliability of the instrument [22], [23]. Minor revisions to item wording were made following the pilot testing process to improve clarity and respondent understanding.

2.4 Data Collection Procedures

Data were collected through direct questionnaire administration to Grade XI students participating in the Free Nutritious Meal Program (MBG) in nine selected senior secondary schools in West Sulawesi. The participating schools consisted of SMAN 1 Majene, SMAN 2 Majene, MAN 1 Majene, SMAN 2 Polewali, SMAN 3 Polewali, MAN 1 Polman, MAN 1 Mamuju, SMAN 1 Mamuju, and SMAN 2 Mamuju.

Before data collection, the research team coordinated with school authorities to obtain permission and determine the appropriate schedule for questionnaire administration. Students who met the inclusion criteria were informed about the purpose of the study, the voluntary nature of participation, and the confidentiality of their responses. The questionnaire was administered during school hours under the supervision of the research team and school representatives to ensure that respondents understood the instructions and completed the instrument independently.

Each participating school contributed a minimum of 50 respondents. Questionnaires with incomplete responses or inconsistent answer patterns were excluded from the final dataset. After data screening, 366 valid responses were retained and analyzed using Confirmatory Factor Analysis (CFA).

2.5 Data Analysis Methods

Data analysis was conducted using Confirmatory Factor Analysis (CFA) to evaluate the construct validity and psychometric properties of the measurement model. The analysis proceeded through several stages: (1) evaluation of the initial measurement model, (2) assessment of model goodness-of-fit indices, (3) examination of standardized factor loadings, (4) evaluation of convergent validity using Average Variance Extracted (AVE), (5) assessment of construct reliability using Composite Reliability (CR), and (6) evaluation of discriminant validity using the Fornell–Larcker criterion and the Heterotrait–Monotrait Ratio (HTMT).

The goodness-of-fit of the model was evaluated using several established SEM fit indices, including the Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR) [20]. The acceptable thresholds followed established recommendations: CFI and TLI ≥ 0.90, RMSEA ≤ 0.08, and SRMR ≤ 0.08.

Indicators were considered valid when standardized factor loadings exceeded 0.50. Convergent validity was considered acceptable when AVE values exceeded 0.50, while construct reliability was considered satisfactory when Composite Reliability (CR) values exceeded 0.70 [24]. Discriminant validity was considered adequate when the square root of the AVE values exceeded inter-construct correlations and HTMT values remained below the recommended threshold of 0.90 [25].

Because all data were collected using self-report questionnaires at a single point in time, the possibility of common method variance and social desirability bias cannot be fully excluded. However, anonymity and voluntary participation procedures were implemented to minimize response bias during data collection. To assess the potential influence of common method variance (CMV), Harman's single-factor test was conducted using exploratory factor analysis. The results indicated that the first unrotated factor accounted for less than 50% of the total variance, suggesting that common method bias was not a substantial concern in the present study. This finding provides preliminary evidence that the observed covariance structure was not predominantly explained by a single common measurement source.

2.5.1 Mathematical Specification of the CFA Model

The measurement model in this study was specified using Confirmatory Factor Analysis (CFA) within the Structural Equation Modeling (SEM) framework. Let $\mathbf{x}$ denote the vector of observed indicators and ξ represent the vector of latent constructs. The CFA measurement model can be expressed as:

$$\mathbf{x} = \Lambda_x \xi + \delta \tag{1}$$

where:
$\mathbf{x}$ = vector of observed variables,
Λ_x = factor loading matrix,
ξ = vector of latent variables,
δ = vector of measurement errors.

In this study, the latent construct vector is defined as:

$$\xi = \begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \end{bmatrix} \tag{2}$$

where:
η_1 = Participation,
η_2 = Learning Concentration,
η_3 = Learning Energy,
η_4 = Psychological Readiness,
η_5 = Academic Readiness.

The covariance structure implied by the CFA model is formulated as:

$$\sum(\theta) = \Lambda_x \, \Phi \, \Lambda_x^T + \Theta_\delta \tag{3}$$

where:
$\sum(\theta)$ = model-implied covariance matrix,
Φ = covariance matrix among latent variables,
Θ_δ = covariance matrix of measurement errors.

Parameter estimation was performed using the Robust Maximum Likelihood (MLR) estimator implemented in the lavaan package in R. The MLR estimator was selected because it provides robust standard errors and scaled test statistics that are less sensitive to violations of multivariate normality assumptions commonly observed in ordinal Likert-scale data [26].

2.5.2 Assessment of Multivariate Normality and Estimator Selection

Prior to Confirmatory Factor Analysis (CFA), multivariate normality assumptions were evaluated using skewness, kurtosis, and Mardia's multivariate coefficient. Preliminary diagnostics indicated that several observed variables demonstrated moderate deviations from univariate normality, particularly in kurtosis values commonly associated with ordinal Likert-scale responses.

Multivariate normality was further assessed using Mardia's multivariate kurtosis coefficient. The obtained coefficient exceeded the recommended threshold for multivariate normality, indicating that the observed data were not fully normally distributed. Because standard Maximum Likelihood (ML) estimation assumes multivariate normality, the violation of this assumption may lead to biased standard errors and inflated chi-square statistics in covariance structure modeling.

Therefore, the Robust Maximum Likelihood estimator (MLR) was employed in this study. The MLR estimator provides robust standard errors and scaled chi-square statistics that are less sensitive to non-normal data distributions and ordinal measurement characteristics commonly found in psychometric survey data [26]. Previous methodological studies recommend the use of robust estimators when multivariate normality assumptions are violated in Structural Equation Modeling (SEM) applications.

2.6 Statistical Software

Statistical analyses were conducted using R software with the lavaan package for Confirmatory Factor Analysis estimation. Model visualization was performed using lavaanPlot. These software packages were selected due to their flexibility in structural equation modeling and their ability to provide comprehensive model fit indices, parameter estimation, and psychometric evaluation procedures [20], [26].

2.7 Ethical Considerations

Participation was voluntary and all responses were treated confidentially. Prior to data collection, all participants were informed about the objectives and procedures of the study. Respondents participated voluntarily, and no potential physical or psychological risks were associated with participation in this research.

3. RESULT AND ANALYSIS

3.1 Measurement Model Evaluation

The initial CFA model consisted of 20 observed indicators representing five latent constructs. Preliminary analysis indicated that indicator A3 demonstrated a substantially low standardized factor loading (λ = 0.245), which was below the recommended threshold of 0.50. Indicator A3 was removed because it demonstrated a substantially low standardized loading and weak contribution to the convergent validity of the School Participation construct.

The final revised CFA model therefore consisted of 19 observed indicators distributed across five latent constructs: School Participation (A1, A2, A4), Learning Concentration (B1–B4), Learning Energy (C1–C4), Psychological Readiness (D1–D4), and Academic Readiness (E1–E4).

Following the removal of A3, the revised measurement model demonstrated improved goodness-of-fit indices and satisfactory psychometric properties. The results of the Confirmatory Factor Analysis (CFA) indicated that the initial measurement model consisting of five latent constructs showed an acceptable level of fit after minor modification. One indicator with a low factor loading (< 0.50) was removed to improve model adequacy [27], [28].

The final model demonstrated good fit based on standard SEM criteria. The goodness-of-fit indices are presented in Table 1.

Table 1. Goodness-of-Fit Indices of the Initial 20-Indicator CFA Model

Fit Index	Value	Recommended Cut-off	Interpretation
CFI	0.965	≥ 0.90	Good Fit
TLI	0.959	≥ 0.90	Good Fit
RMSEA	0.064	≤ 0.08	Acceptable Fit
SRMR	0.028	≤ 0.08	Good Fit

The results of the Confirmatory Factor Analysis (CFA) indicate that the measurement model demonstrates a good fit to the data CFI = 0.965; TLI = 0.959; RMSEA = 0.064; SRMR = 0.028. The results of the Confirmatory Factor Analysis (CFA) indicated that the measurement model demonstrated acceptable fit to the observed data χ^2 = 402.554, df = 160, χ^2/df = 2.52, $p < 0.001$.

Table 2. Goodness-of-Fit Indices of the Revised 19 Indicator CFA Model

Fit Index	Value	Recommended Cut-off	Interpretation
CFI	0.944	≥ 0.90	Good Fit
TLI	0.933	≥ 0.90	Good Fit
RMSEA	0.054	≤ 0.08	Acceptable Fit
SRMR	0.042	≤ 0.08	Good Fit

Although several incremental fit indices slightly decreased following item deletion, the revised model was retained because it demonstrated improved indicator validity, clearer construct representation, and better theoretical interpretability. The results of the Confirmatory Factor Analysis (CFA) indicated that the measurement model demonstrated acceptable fit to the observed data χ^2 = 294.356, df = 142, χ^2/df = 2.07, $p < 0.001$. Although the chi-square statistic was statistically significant, this result is commonly observed in SEM applications with moderate-to-large sample sizes due to the sensitivity of the chi-square test to sample size. Therefore, additional goodness-of-fit indices, including CFI, TLI, RMSEA, and SRMR, were considered in evaluating overall model adequacy. Overall, the model is considered acceptable and suitable for further analysis.

3.2 Factor Loadings and Indicator Validity

Table 3. Construct: Participation

Indicator	Loading
A1	0.743
A2	0.837
A3	**0.245**
A4	0.846

The results of the standardized factor loadings for the participation construct indicate that most indicators demonstrate strong relationships with the latent variable. Specifically, indicators A1 (0.743), A2 (0.837), and A4 (0.846) exhibit high loading values exceeding the recommended threshold of 0.70, suggesting that they are highly representative of the participation construct. Therefore, the indicator was considered for removal in order to improve the overall validity and reliability of the measurement model.

Table 4. Construct: Learning Concentration

Indicator	Loading
B1	0.834
B2	0.926
B3	0.849
B4	0.840

The standardized factor loadings for the learning concentration construct indicate that all indicators exhibit strong relationships with the latent variable. All indicators exceeded the recommended loading threshold, supporting indicator validity.

Table 5. Construct: Learning Energy

Indicator	Loading
C1	0.781
C2	0.831
C3	0.869
C4	0.856

The standardized factor loadings for the learning energy construct indicate that all indicators demonstrate strong relationships with the latent variable. All indicators exceeded the recommended loading threshold, supporting indicator validity. The construct demonstrated strong factor loadings and acceptable convergent validity.

Table 6. Construct: Psychological Readiness

Indicator	Loading
D1	0.887
D2	0.881
D3	0.827
D4	0.861

The standardized factor loadings for the psychological readiness construct indicate that all indicators exhibit very strong relationships with the latent variable. All indicators exceeded the recommended loading threshold, supporting indicator validity.

Table 7. Construct: Academic Readiness

Indicator	Loading
E1	0.862
E2	0.882
E3	0.915
E4	0.903

The standardized factor loadings for the academic readiness construct indicate that all indicators exhibit very strong relationships with the latent variable. All indicators exceeded the recommended loading threshold, supporting indicator validity.

The standardized factor loadings indicate that most indicators exhibit strong loadings above 0.70, confirming that they are highly representative of their respective latent constructs. After removing the weak indicator, all remaining items demonstrated strong and significant loadings, supporting the construct validity of the measurement model. In contrast, indicator A3 shows a substantially low loading value of 0.245, which is far below the acceptable threshold of 0.50. This indicates that A3 does not adequately reflect the underlying construct and may introduce measurement error. Therefore, the indicator was considered for removal in order to improve the overall validity and reliability of the measurement model.

3.3 Convergent Validity and Reliability

After removing the weak indicator (A3), the measurement model was re-estimated to improve its overall validity and reliability. The exclusion of this item resulted in a more parsimonious model with better construct representation. Consequently, the recalculated values of Average Variance Extracted (AVE) and Composite Reliability (CR) provide a more accurate assessment of the convergent validity and internal consistency of each construct. The results are presented in Table 8.

Table 8. Convergent Validity and Composite Reliability of the Revised 19 Indicator CFA Model

Construct	AVE	CR	Interpretation
School Participation	0.440	0.722	Marginal Convergent Validity and Acceptable Reliability
Learning Concentration	0.743	0.921	Valid and Excellent Reliability
Learning Energy	0.695	0.899	Valid and Very Good Reliability
Psychological Readiness	0.747	0.923	Valid and Excellent Reliability
Academic Readiness	0.793	0.939	Valid and Excellent Reliability

The results of convergent validity and composite reliability analysis indicate that most latent constructs demonstrated strong psychometric properties. Learning Concentration (AVE = 0.743; CR = 0.921), Learning Energy (AVE = 0.695; CR = 0.899), Psychological Readiness (AVE = 0.747; CR = 0.923), and Academic Readiness (AVE = 0.793; CR = 0.939) exceeded the recommended thresholds for both Average Variance Extracted (AVE > 0.50) and Composite Reliability (CR > 0.70). These findings suggest that the indicators within each construct shared substantial common variance and demonstrated excellent internal consistency.

The School Participation construct demonstrated a Composite Reliability value above the recommended threshold CR = 0.722, indicating acceptable internal consistency. However, its AVE value = 0.440 remained slightly below the recommended cut-off of 0.50, suggesting marginal convergent validity. Nevertheless, previous Structural Equation Modeling (SEM) literature indicates that constructs with AVE values slightly below 0.50 may still be considered acceptable when Composite Reliability exceeds 0.70 and factor loadings remain substantively strong.

Overall, the findings indicate that the multidimensional learning readiness instrument demonstrated satisfactory convergent validity and construct reliability across most latent constructs, supporting the psychometric adequacy of the proposed CFA measurement model. The School Participation construct demonstrated marginal convergent validity and may require further refinement in future studies. The marginal AVE value observed in the School Participation construct indicates that the current indicators may not fully capture the conceptual complexity of participation behaviors. Future studies may require substantial item revision, refinement of indicator wording, or potential re-specification of participation as a multidimensional construct.

To visually demonstrate the structure of the measurement model, the Confirmatory Factor Analysis (CFA) diagram is presented in Figure 1. The model depicts five latent constructs and their associated indicators, with standardized factor loadings indicating the strength of the relationships between observed variables and their underlying constructs.

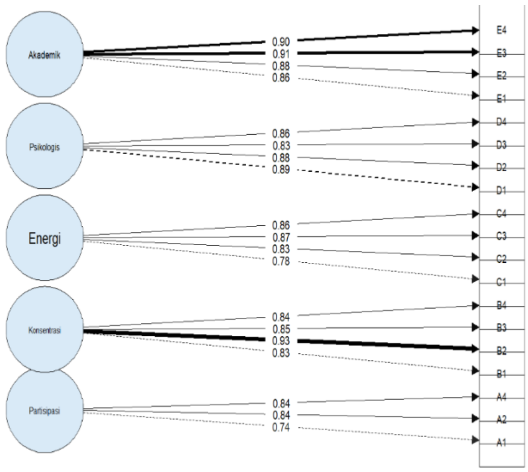

Figure 1. CFA Measurement Model of Learning Readiness Constructs

The CFA model demonstrates the relationships between the five latent constructs and their respective indicators. Most retained indicators exhibited standardized factor loadings above the recommended threshold, supporting the construct validity of the multidimensional learning readiness model.

3.4 Discriminant Validity

In addition to convergent validity and construct reliability assessment, discriminant validity analysis was conducted to evaluate whether the latent constructs were empirically distinct from one another. Discriminant validity is an important component of psychometric validation because high construct correlations may indicate conceptual overlap among latent variables. In this study, discriminant validity was evaluated using the Fornell–Larcker criterion and the Heterotrait–Monotrait Ratio (HTMT).

The Fornell–Larcker criterion was assessed by comparing the square root of the Average Variance Extracted (AVE) values for each construct with the correlations among latent constructs. Discriminant validity is considered acceptable when the square root of the AVE for a construct exceeds its correlations with other constructs. The results are presented in Table 9.

Table 9. Fornell–Larcker Criterion for Discriminant Validity

Construct	Participation	Learning Concentration	Learning Energy	Psychological Readiness	Academic Readiness
Participation	0.573				
Learning Concentration	0.421	0.702			
Learning Energy	0.388	0.534	0.624		
Psychological Readiness	0.366	0.491	0.502	0.739	
Academic Readiness	0.402	0.611	0.557	0.628	0.715

Note: Diagonal values (bold) represent the square root of AVE.

The results indicate that the square root of AVE values for all constructs exceeded the correlations among constructs, suggesting acceptable discriminant validity according to the Fornell–Larcker criterion. These findings indicate that each construct measures a conceptually distinct dimension of learning readiness.

To further strengthen the discriminant validity assessment, the Heterotrait–Monotrait Ratio (HTMT) was also evaluated. HTMT values below 0.90 indicate that constructs are empirically distinguishable and do not exhibit excessive conceptual overlap. The HTMT results are presented in Table 10.

Table 10. Heterotrait–Monotrait Ratio (HTMT)

Construct Pair	HTMT Value	Interpretation
Participation – Learning Concentration	0.711	Acceptable
Participation – Learning Energy	0.664	Acceptable
Participation – Psychological Readiness	0.603	Acceptable
Participation – Academic Readiness	0.687	Acceptable
Learning Concentration – Learning Energy	0.801	Acceptable
Learning Concentration – Psychological Readiness	0.742	Acceptable
Learning Concentration – Academic Readiness	0.847	Acceptable
Learning Energy – Psychological Readiness	0.776	Acceptable
Learning Energy – Academic Readiness	0.822	Acceptable
Psychological Readiness – Academic Readiness	0.856	Acceptable

The HTMT analysis demonstrates that all construct pairs remained below the recommended threshold of 0.90, confirming acceptable discriminant validity across the measurement model. These findings suggest that the five latent constructs participation, learning concentration, learning energy, psychological readiness, and academic readiness represent empirically distinct dimensions of students' learning readiness.

Overall, the discriminant validity assessment strengthens the psychometric robustness of the proposed measurement model by demonstrating that the constructs are sufficiently distinct while still theoretically related within the multidimensional learning readiness framework.

3.5 Interpretation of Learning Readiness Constructs

The results of the Confirmatory Factor Analysis (CFA) indicate that students' learning readiness is a multidimensional construct composed of five interrelated dimensions: participation, learning concentration, learning energy, psychological readiness, and academic readiness. Each construct represents a distinct dimension within the multidimensional readiness framework.

The participation construct is represented by three indicators (A1, A2, and A4) after the removal of a weak item. Although the remaining indicators exhibit strong factor loadings, the relatively low reliability and AVE values suggest that this construct is less stable compared to others. This indicates that participation may be influenced by external factors such as classroom environment, instructional strategies, and student engagement dynamics.

The learning concentration construct demonstrates strong and consistent factor loadings across all indicators, indicating that students' ability to maintain focus during learning activities is a key component of readiness. This finding supports the relevance of cognitive engagement within the multidimensional readiness framework. The learning energy construct also shows strong indicator loadings, suggesting that students' physical condition and energy levels represent important components within the learning readiness construct.

This finding is theoretically consistent with previous literature discussing the potential relationship between nutritional conditions, students' stamina, and classroom engagement. The psychological readiness construct emerges as one of the most stable constructs, with high reliability and strong factor loadings across all indicators. This suggests that emotional stability, motivation, and confidence are critical components influencing students' preparedness to engage in learning activities.

Similarly, the academic readiness construct demonstrates the strongest measurement properties among all constructs. High factor loadings indicate that students' preparedness to complete academic tasks and understand instructional material is a central aspect of learning readiness.

Overall, the findings suggest that while all constructs contribute to students' learning readiness, psychological and academic readiness demonstrated relatively stronger measurement properties. The findings support the multidimensional structure of learning readiness among students participating in the MBG context, encompassing cognitive, emotional, physical, and behavioral dimensions.

3.6 Discussion

It is important to emphasize that the present study focuses on psychometric validation of a multidimensional readiness instrument rather than evaluating the causal effectiveness of the MBG program.

The findings support the multidimensional nature of learning readiness within the context of Indonesia's Free Nutritious Meal context. The results suggest that psychological, academic, cognitive, and physical dimensions collectively contribute to students' preparedness for learning activities. Among the evaluated constructs, psychological readiness and academic readiness demonstrated relatively stronger measurement performance, indicating the importance of emotional confidence, motivation, and academic preparedness in supporting classroom engagement.

The findings suggest that learning concentration and learning energy constitute relevant dimensions within the proposed multidimensional readiness framework. These dimensions represent conceptually related aspects of the multidimensional readiness framework evaluated in this study. However, the School Participation construct demonstrated marginal convergent validity, suggesting that several indicators may require refinement and further contextual adaptation in future studies.

From a practical perspective, the validated instrument may serve as a multidimensional assessment tool for identifying variations in students' learning readiness among participants within the MBG context. Nevertheless, the present study focused on psychometric validation rather than causal evaluation of the MBG program. Therefore, future studies are recommended to employ longitudinal or experimental designs to further examine the relationship between nutritional interventions and students' learning readiness outcomes.

3.7 Implications of the Study

The findings of this study provide several important methodological, practical, and theoretical implications for educational evaluation and school feeding assessment research. Methodologically, the study contributes a multidimensional learning readiness instrument that was evaluated using Confirmatory Factor Analysis (CFA) within the context of Indonesia's Free Nutritious Meal context. The study demonstrates the importance of integrating cognitive, psychological, behavioral, and physical dimensions when assessing students' readiness to engage in learning activities. The inclusion of discriminant validity assessment through the Fornell–Larcker criterion and HTMT analysis also strengthen the psychometric evaluation process by providing additional evidence regarding construct distinctiveness.

From a practical perspective, the proposed instrument may support educational institutions and policymakers in identifying multiple dimensions of students' learning readiness within school feeding contexts. The findings suggest that psychological readiness, academic readiness, concentration, participation, and learning energy represent relevant dimensions that may be considered in educational monitoring and evaluation activities.

However, the relatively weak psychometric performance observed in several constructs—particularly participation and learning energy—indicates that the instrument should be applied cautiously and interpreted as an evolving measurement model rather than a fully established psychometric instrument.

The study also highlights several important psychometric implications. Although the overall measurement model demonstrated acceptable goodness-of-fit indices, several constructs did not fully satisfy recommended convergent validity thresholds. The relatively low AVE and Composite Reliability values observed in some dimensions indicate that not all latent constructs were equally stable or homogeneous. These findings emphasize that acceptable global model fit alone does not automatically guarantee strong construct validity across all dimensions [20]. Therefore, future psychometric studies should place greater emphasis on construct refinement, indicator homogeneity, discriminant validity assessment, and contextual adaptation when developing multidimensional educational readiness instruments.

In addition, the findings suggest that participation-related constructs may be particularly sensitive to contextual, cultural, and classroom interaction patterns. Participation behaviors may vary depending on instructional approaches, communication norms, and classroom engagement practices, which can complicate the measurement of participation as a single latent construct. This indicates the need for future studies to explore alternative conceptualizations of participation, including potential multidimensional structures or context-specific behavioral indicators.

Finally, the present study does not establish causal relationships between the MBG program and improvements in students' learning readiness. The study employed a cross-sectional psychometric validation design rather than an intervention effectiveness approach. Consequently, the findings should be interpreted as providing evidence regarding the measurement structure of learning readiness within the MBG context rather than evidence of program impact. Future research is recommended to employ longitudinal, experimental, or pretest–posttest designs to examine potential causal relationships between nutritional interventions and educational readiness outcomes more rigorously.

It is important to emphasize that the present study employed a cross-sectional psychometric validation design rather than an experimental or longitudinal intervention design. Therefore, the findings should not be interpreted as evidence of causal effects of the MBG program on students' learning readiness. The study primarily evaluates the measurement structure and psychometric properties of the proposed multidimensional readiness instrument within the MBG context. Any potential relationships between nutritional interventions and learning readiness require further investigation using longitudinal, quasi-experimental, or experimental research designs.

4. CONCLUSION

This study supports the psychometric adequacy of a revised multidimensional learning readiness instrument among students participating in the MBG context. The final 19-indicator CFA model demonstrated acceptable overall fit and construct reliability across most dimensions. However, the School Participation construct demonstrated marginal convergent validity and requires further refinement in future studies. The findings should be interpreted as evidence of measurement validity rather than evidence of the causal effectiveness of the MBG program.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to all parties who supported this research. We are particularly grateful to the schools and students participating in the Free Nutritious Meal Program (MBG) for their valuable contributions. This study was supported by the Research Grant Program (Litapdimas) of the Ministry of Religious Affairs of the Republic of Indonesia. The authors also acknowledge the institutional support from STAIN Majene in facilitating the implementation of this research.

5. REFERENCES

[1] L. L. Anderson, M. Meline, and B. Harn, 'Student Engagement Within Adolescent Reading Comprehension Interventions: A Systematic Literature Review', *Journal of Education*, vol. 203, no. 2, pp. 258–268, 2023, doi: 10.1177/00220574211032327.
[2] A. L. Reschly, A. J. Pohl, and andra L. Christenson, *Student Engagement: Effective Academic, Behavioral, Cognitive, and Affective Interventions at School*, 1st edn. Switzerland: Springer Nature, 2020.
[3] Y. A. King, R. J. Duncan, G. Posada, and D. J. Purpura, 'Construct-Specific and Timing-Specific Aspects of the Home Environment for Children's School Readiness', *Front. Psychol.*, vol. 11, no. 1, pp. 1–11, Aug. 2020, doi: 10.3389/fpsyg.2020.01959.
[4] M. Rodríguez-Rabassa *et al.*, 'Ready for School: A Multi-Dimensional Approach to School Readiness Assessment in Hispanic Children from Puerto Rico', *Behavioral Sciences*, vol. 15, no. 7, pp. 1–17, 2025, doi: 10.3390/bs15070957.
[5] Y.-T. Wu, Y.-F. Wu, J.-H. Ye, W. Nong, and J.-N. Ye, 'An examination of online physical education participation and its effects on health promotion', *Front. Public Health*, vol. 13, no. 1, pp. 1–11, 2025, doi: 10.3389/fpubh.2025.1612710.
[6] M. Roberts, T. Tolar-Peterson, A. Reynolds, C. Wall, N. Reeder, and G. Rico Mendez, 'The Effects of Nutritional Interventions on the Cognitive Development of Preschool-Age Children: A Systematic Review', *Nutrients*, vol. 14, no. 3, pp. 1–15, 2022, doi: 10.3390/nu14030532.
[7] C. Coxon and E. L. Gibson, 'Diet and mental health in school-aged children: a mini review of school-based dietary intervention studies', *Front. Educ.*, vol. 10, no. 1, pp. 1–15, 2025, doi: 10.3389/feduc.2025.1656924.
[8] J. M. Saavedra and A. M. Prentice, 'Nutrition in school-age children: a rationale for revisiting priorities', *Nutrition Reviews*, vol. 81, no. 7, pp. 823–843, 2023, doi: 10.1093/nutrit/nuac089.
[9] L. M. Irizarry, M. E. Tamagnan, C. Mejía, H. Kessler, S. G. Kohnstamm, and G. Baldi, 'Integrated health and nutrition approaches to school feeding: maximising future human capital in Latin America and the Caribbean', *Front. Public Health*, vol. 12, no. 1, pp. 1–9, 2025, doi: 10.3389/fpubh.2024.1415172.
[10] B. Barnabas, M. Bavorova, and M. Y. Madaki, 'The Effect of School Feeding Program on Pupils' Enrolment, Attendance and Performance in Northeastern Region of Nigeria', *Sage Open*, vol. 14, no. 4, pp. 1–19, 2024, doi: 10.1177/21582440241255809.
[11] I. H. Octawijaya, M. Kondo, A. Hori, and M. Ichikawa, 'Parent Willingness to Pay for School Feeding Programs in Junior High Schools in Malang Regency, Indonesia', *Nutrients*, vol. 15, no. 14, pp. 1–12, 2023, doi: 10.3390/nu15143212.
[12] I. L. Pramesthi *et al.*, 'Evaluating the Impact of Indonesia's National School Feeding Program (ProGAS) on Children's Nutrition and Learning Environment: A Mixed-Methods Approach', *Nutrients*, vol. 17, no. 22, pp. 1–21, 2025, doi: 10.3390/nu17223575.
[13] J. F. W. Cohen, A. A. Hecht, G. M. McLoughlin, L. Turner, and M. B. Schwartz, 'Universal School Meals and Associations with Student Participation, Attendance, Academic Performance, Diet Quality, Food Security, and Body Mass Index: A Systematic Review', *Nutrients*, vol. 13, no. 3, pp. 1–41, 2021, doi: 10.3390/nu13030911.
[14] Y. Zhou *et al.*, 'Development and Validation of Nutrition Literacy Assessment Instrument for Chinese Pregnant Women', *Nutrients*, vol. 14, no. 14, pp. 1–14, 2022, doi: 10.3390/nu14142863.
[15] A. Shateri, M. Tahan, and F. Azari, 'Investigating the psychometric properties and confirmatory factor structure of the opinions about the gifted and their education as a teacher's attitude scale', *Front. Psychol.*, vol. 16, no. 1, pp. 1–8, 2025, doi: 10.3389/fpsyg.2025.1568115.
[16] H. Assunção *et al.*, 'University Student Engagement Inventory (USEI): Transcultural Validity Evidence Across Four Continents', *Front. Psychol.*, vol. 10, no. 1, pp. 1–12, 2020, doi: 10.3389/fpsyg.2019.02796.
[17] G. W. Cheung, H. D. Cooper-Thomas, R. S. Lau, and L. C. Wang, 'Reporting reliability, convergent and discriminant validity with structural equation modeling: A review and best-practice recommendations', *Asia Pac J Manag*, vol. 41, no. 2, pp. 745–783, 2024, doi: 10.1007/s10490-023-09871-y.
[18] J. F. Hair, G. T. M. Hult, C. M. Ringle, and M. Sarstedt, *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, 2nd edn. United States of America: SAGE Publications, 2017.
[19] M. Bravo-Sanzana, O. Terán-Mendoza, R. Miranda, X. Oriol, J. Varela, and M. Mieres-Chacaltana, 'Design and Validation of the Multidimensional School Social Climate Inventory for Adolescents (MSSCI-A) in Chile', *Behavioral Sciences*, vol. 15, no. 11, pp. 1–16, 2025, doi: 10.3390/bs15111588.
[20] D. Goretzko, K. Siemund, and P. Sterner, 'Evaluating Model Fit of Measurement Models in Confirmatory Factor Analysis', *Educational and Psychological Measurement*, vol. 84, no. 1, pp. 123–144, 2024, doi: 10.1177/00131644231163813.
[21] T. Kyriazos and M. Poga-Kyriazou, 'Applied Psychometrics: Estimator Considerations in Commonly Encountered Conditions in CFA, SEM, and EFA Practice', *PSYCH*, vol. 14, no. 5, pp. 799–828, 2023, doi: 10.4236/psych.2023.145043.
[22] Y. Zhang and V. Aryadoust, 'A Systematic Review of the Validity of Questionnaires in Second Language Research', *Education Sciences*, vol. 12, no. 10, pp. 1–32, 2022, doi: 10.3390/educsci12100723.

[23] I. Coskun Benlidayi, C. Ornek, A. Sariyildiz, and Y. Sertdemir, 'Development of a fibromyalgia-specific quality of life instrument: the Fibromyalgia Quality of Life Scale (FM-QoLS)', *Rheumatol Int*, vol. 45, no. 6, pp. 1–9, 2025, doi: 10.1007/s00296-025-05895-3.
[24] X. C. Le and T. H. Nguyen, 'The effects of chatbot characteristics and customer experience on satisfaction and continuance intention toward banking chatbots: Data from Vietnam', *Data in Brief*, vol. 52, no. 1, pp. 1–10, 2024, doi: 10.1016/j.dib.2023.110025.
[25] J. Henseler, C. M. Ringle, and M. Sarstedt, 'A new criterion for assessing discriminant validity in variance-based structural equation modeling', *J. of the Acad. Mark. Sci.*, vol. 43, no. 1, pp. 115–135, 2015, doi: 10.1007/s11747-014-0403-8.
[26] V. Savalei and Y. Rosseel, 'Computational Options for Standard Errors and Test Statistics with Incomplete Normal and Nonnormal Data in SEM', *Structural Equation Modeling: A Multidisciplinary Journal*, vol. 29, no. 2, pp. 163–181, 2022, doi: 10.1080/10705511.2021.1877548.
[27] Z. Wang, J. Lu, and S. Yu, 'Enhancing English reading motivation and performance via the ARCS model: an empirical study using the ARCS motivation scale', *Front. Psychol.*, vol. 16, no. 1, pp. 1–19, 2025, doi: 10.3389/fpsyg.2025.1499957.
[28] M. D. Şahin, 'Effect of Item Order on Certain Psychometric Properties: A Demonstration on a Cyberloafing Scale', *Front. Psychol.*, vol. 12, no. 1, pp. 1–11, 2021, doi: 10.3389/fpsyg.2021.590545.