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EDITED BY

Jairo Rodríguez-Medina,
University of Valladolid, Spain

REVIEWED BY

Soo Lee,
American Institutes for Research,
United States
Samuel Honório,
Polytechnic Institute of Castelo
Branco, Portugal

*CORRESPONDENCE

Jennifer Sobeida Moreira-Choez
✉ jennifer.moreira@utm.edu.ec

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Measurement through structural equations of the self-concept instrument in high-school students

Angel Ramón Sabando-García¹,
Oswaldo José Jiménez-Bustillo², Lidia Janeth Llacsá-Puma³,
Graciela Josefina Castro-Castillo²,
Jennifer Sobeida Moreira-Choez^{4*} and
Raúl Alberto Rengifo-Lozano⁵

¹School of Administrative and Accounting Sciences at the Catholic University of Ecuador, Santo Domingo, Ecuador, ²Language and Literature Pedagogy Program and Graduate School at Milagro State University, Milagro, Ecuador, ³Graduate School at Milagro State University, Milagro, Ecuador, ⁴Department of Basic Sciences, Faculty of Mathematics and Statistics, Technical University of Manabí, Portoviejo, Ecuador, ⁵Faculty of Economic Sciences at the National University Mayor, Lima, Peru

Introduction: Self-concept is a fundamental component of psychological and educational development, playing a critical role in students' academic performance and emotional wellbeing. Despite its importance, gaps remain in the validation of measurement instruments tailored to specific educational contexts.

Methods: This study employed a quantitative, predictive, and correlational methodology with a non-experimental cross-sectional design. A total of 172 adolescents from grades 8, 9, and 10 in a school in Santo Domingo, Ecuador, were selected through non-probabilistic convenience sampling. The Self-Concept Questionnaire FORM-5 (AF-5), which evaluates academic/occupational, social, emotional, family, and physical self-concepts, was administered. Data analysis utilized SPSS version 25 and AMOS 24 software to ensure reliability and validity through structural equation modeling.

Results: The AF-5 demonstrated high reliability, with a Cronbach's alpha of 0.854. Gender differences were observed, with females scoring higher in emotional self-concept and males excelling in physical self-concept. Structural equation modeling confirmed the instrument's significant factor loadings, validating its application in measuring self-concept.

Discussion: The findings highlight the robustness and applicability of the AF-5 in educational contexts, providing a validated tool to assess self-concept dimensions among upper elementary students. The study underscores the importance of using reliable instruments to better understand and support students' academic and emotional development. Further research is recommended to explore the instrument's application across diverse populations.

KEYWORDS

self-concept, secondary education, structural equations, instrument validation, factor analysis

1 Introduction

Currently, structural equations, complemented by confirmatory factor analysis (CFA) and principal component analysis (PCA), are essential tools in the evaluation of self-concept in elementary-level students (Beasley and McClain, 2021; Bofah and Hannula, 2015). These methodologies allow for precise identification and validation of the

underlying factors of academic self-concept and its relationship with other motivational constructs (Petersen et al., 2023). In this context, the Self-Concept Questionnaire FORMA-5 (AF-5) emerges as a widely used and validated instrument for measuring various dimensions of self-concept in adolescents and young adults (Méndez-Giménez et al., 2017). Originally developed to assess five key dimensions of self-concept academic, social, emotional, family, and physical the AF-5 offers a robust factorial structure that has proven useful in educational settings for exploring the relationship between self-concept and academic achievement (Chen et al., 2020; Zurita-Ortega et al., 2023).

The structure of the AF-5 enables a comprehensive evaluation of these dimensions, facilitating the distinction between different facets of self-concept, which is crucial for understanding its impact on variables such as motivation and academic self-efficacy. Recent studies have confirmed the internal consistency and reliability of the AF-5 across various age groups and cultural contexts, with reliability coefficients exceeding 0.80 in all dimensions (Lobaton Gonzales et al., 2024; Osorio Castaño et al., 2024). This instrument is administered through a Likert-type scale format, where participants rate statements related to their self-perception in each dimension. The validated version of the AF-5 has been used in multiple studies to examine how self-concept functions as a predictor of academic achievement and autonomous motivation, supporting self-determination theories regarding basic psychological needs (Lu et al., 2017; Ustun, 2023; Valero-Valenzuela et al., 2021).

Structural equation modeling has been widely applied with the AF-5 to investigate the relationships between psychological and educational factors, showing strong results that support the validity of this instrument (Cuadra-Martínez et al., 2022; Fiedler and Spychiger, 2017). Additionally, the removal of non-significant items in the renewal of the AF-5's factor model has allowed for adequate reliability indices, validating its application in measuring self-concept in adolescents. The combination of the AF-5 with structural models and factor analyses has proven effective in comparing different structural models and examining the stability of effects over time, demonstrating its relevance in longitudinal studies on academic self-concept and educational achievement (Gorges and Hollmann, 2019; Marsh et al., 2022).

On the other hand, existing literature highlights that individual items can provide valid and reliable assessments of psychological phenomena such as self-concept and academic values (Beymer et al., 2022). Research has revealed that self-concept is a significant predictor of academic achievement, particularly in science, and is related to autonomous motivation, thus supporting self-determination theories regarding basic psychological needs (Lu et al., 2017; Ustun, 2023; Valero-Valenzuela et al., 2021).

The assessment of self-concept through structural equation models and confirmatory factor analysis enables the comparison of different structural models and the examination of stability and directional effects over time (Gorges and Hollmann, 2019; Marsh et al., 2022). Studies have used multi-group structural equation models to investigate how academic self-concept predicts educational aspirations, finding that both academic self-concept and interest in reading are significant predictors in different groups (Korhonen et al., 2016).

Furthermore, the visual representation of qualitative data associated with content validity analysis is crucial for visualizing the weight of dimensions in each item and the content validity coefficient (García-Sánchez et al., 2022). Analyses suggest that self-concept acts as a mediating factor in the relationship between resilience and academic achievement, although there is no direct relationship between resilience and emotional intelligence with academic performance (García-Martínez et al., 2022).

Moreover, academic self-concept is not only a key predictor of academic achievement but also significantly influences desirable educational outcomes (Arens et al., 2021; Hausen et al., 2022). The relationship between academic performance and self-concept is bidirectional, positively affecting within the same domain and negatively in others (Möller et al., 2020; Sticca et al., 2023). Additionally, specific ability self-concept is a crucial predictor of grades in various subjects, highlighting its importance in educational development (Van der Westhuizen et al., 2022).

Despite the extensive body of research on academic self-concept, significant gaps remain. Most studies focus on specific populations and educational contexts, limiting the generalization of findings to different settings and stages of academic development. Furthermore, the relationship between self-concept and other psychological and educational factors, such as resilience and emotional intelligence, remains insufficiently explored. Existing studies often use methodologies that do not always capture the complexity of the interactions between these constructs.

In this context, the need for this research is grounded in addressing these gaps and expanding the understanding of how academic self-concept influences students' performance and wellbeing throughout their educational journey. This research aims to validate the self-concept instrument in upper elementary school students using structural equations. From this perspective, the study proposes the following hypotheses:

- H1: The observed and unobserved variables of self-concept possess acceptable reliability.
- H2: The factor loadings of the items and dimensions of self-concept present acceptable coefficients through the best fit model technique.
- H3: Students' self-concepts exhibit the best validity measures of the model through discriminant and convergent validity tests using structural equation techniques and plugins for verification.

2 Materials and methods

This research follows a quantitative, predictive, and correlational methodology, with a non-experimental cross-sectional design. The study participants were 172 adolescents from eighth, ninth, and 10th grades of upper elementary education in Ecuador. The participants' ages ranged from 12 to 15 years, with a minimum age of 12, a maximum of 15, a mean age of 13.46 years, and a standard deviation (SD) of 0.76.

Participants were selected using non-probabilistic convenience sampling. Inclusion criteria included enrollment in eighth, ninth, or 10th grades, written consent from parents or guardians, and

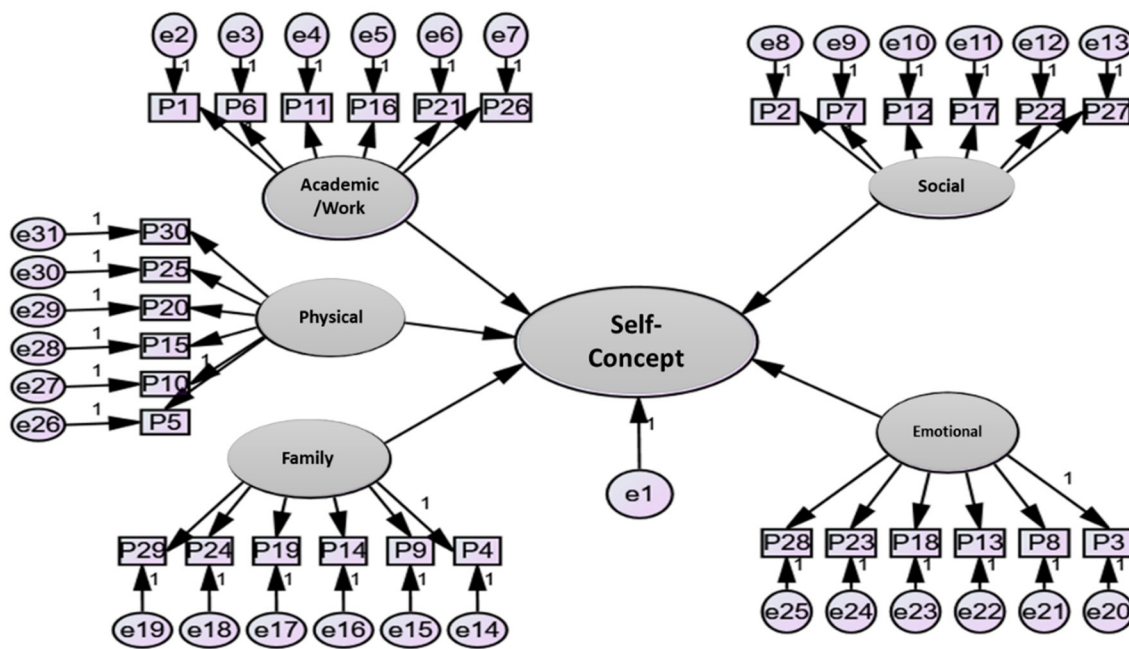


FIGURE 1 Structural equations of self-concept in upper basic education.

complete responses to the Self-Concept Questionnaire FORM-5 (AF-5). Exclusion criteria involved adolescents with cognitive or physical conditions that could hinder their participation or understanding of the survey, as well as incomplete responses to the questionnaire.

Figure 1 presents the structural equation model of self-concept in upper basic education, based on the Self-Concept Questionnaire FORMA-5 (AF-5). This instrument consists of five dimensions or subconstructs: academic/work, social, emotional, family, and physical. Each of these dimensions is represented by six items, totaling 30 observed items or variables.

The academic/work dimension assesses self-concept related to performance and expectations in academic and work environments. The social dimension measures self-concept concerning social interactions and relationships. The emotional dimension focuses on the perception of one’s emotions and emotional stability. The family dimension evaluates self-concept within the family context, while the physical dimension refers to the perception of one’s body and physical abilities.

Each item is associated with a latent factor representing one of the five mentioned dimensions. The model’s structure is validated through confirmatory factor analysis, ensuring the adequacy of fit indices and construct reliability. This model allows a comprehensive understanding of self-concept in adolescents in upper basic education, providing a useful tool for research and educational intervention.

The data analysis and creation of the confirmatory structural equation (CSE) were performed using SPSS and AMOS software (Petersen et al., 2023). The use of these multivariate methods facilitates the verification of indirect effects and the testing of mediation hypotheses, simplifying the process (Castro-González, 2019).

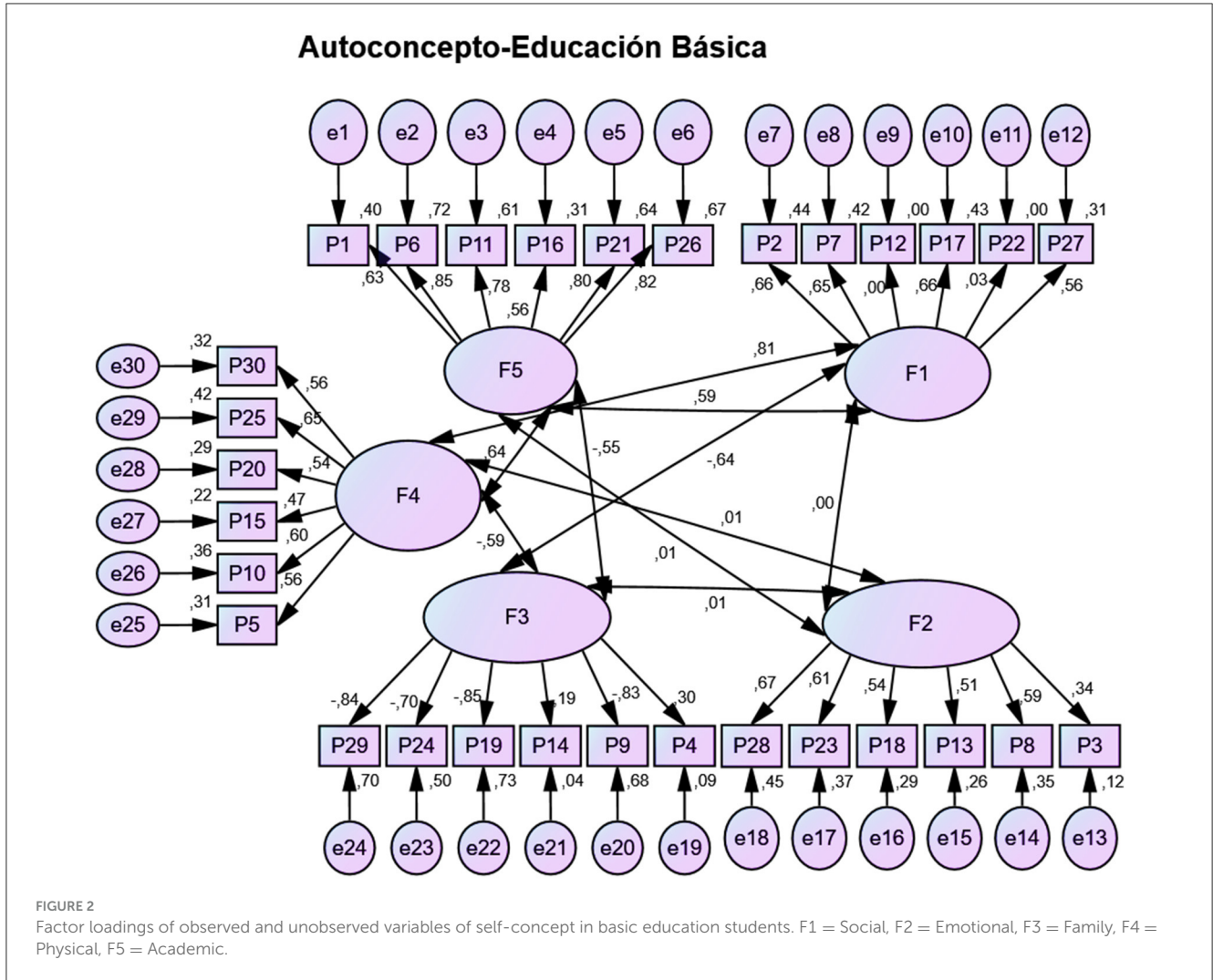
In verifying the coefficients of the best-fitting model obtained through the structural equation, the maximum likelihood test was applied. This approach generated several iterations that produced a significant Chi-square ($p < 0.05$), along with fit indices such as the adjusted goodness-of-fit index (AGFI), the Tucker-Lewis index (TLI), Bentler’s comparative fit index (CFI), the Bayesian information criterion (BIC), the root mean square error of approximation (RMSEA), the standardized root mean square residual (SRMR), and Pclose (Al-Balhan et al., 2018; Crawford and Lamarre Jean, 2021).

This process was validated by downloading plugins such as “model fit measures,” which provide model fit measures, including both quantitative and qualitative parameters (excellent, acceptable, and poor) for each index. Additionally, the “validity and reliability test” plugin facilitated the testing of validity and reliability, yielding results on discriminant validity, convergent validity, and HTMT analysis (Henseler et al., 2015).

3 Results and discussion

The instrument measuring self-concepts demonstrated excellent reliability, with a Cronbach’s alpha of 0.854. Regarding the self-concept dimensions, the following reliability indices were observed: academic/work (0.880), social (0.558), emotional (0.717), family (0.579), and physical (0.735), showing acceptable reliability in most cases.

The results obtained in Figure 2, through the confirmatory structural equation, provide a clear view of the internal structure of self-concepts in upper basic education students. The observed factor loadings in social self-concept (F1) fall within an acceptable range, suggesting a robust representation of this construct. The



values, ranging between 0.56 and 0.66, align with previous findings that emphasize the importance of the social environment in shaping self-concept at this educational stage (Marsh et al., 2023; Sinclair et al., 2019).

In the case of emotional self-concept (F2), the observed variables also reflect adequate consistency, with scores ranging from 0.51 to 0.67, except for item P3, whose factor loading, while significant, is relatively low (0.34). This finding may indicate the need to review or adjust this item to improve the internal consistency of the emotional dimension, in line with recommendations from authors like Clark and Watson (2016), who suggest reviewing items with weak factor loadings to strengthen construct validity.

Family self-concept (F3) showed high, but negative, scores, especially in items P14 and P4, which could be interpreted as possible cognitive dissonance or perceived family conflicts by the students. This phenomenon has been documented in studies exploring the influence of the family environment on self-concept, where conflicting family relationships can negatively impact individuals' self-image (Bellin et al., 2007; Lebudu et al., 2020; Offer et al., 1982).

On the other hand, physical self-concept (F4) presented scores ranging from 0.47 to 0.65, suggesting a moderate but consistent

perception of the physical dimension. This aspect is consistent with research highlighting the importance of physical self-image in the development of self-concept during adolescence, a critical period for identity formation (Crone et al., 2022; Seiffge-Krenke, 1990).

Finally, the factor loadings for academic self-concept (F5) were the most significant, fluctuating between 0.56 and 0.85. These results are consistent with previous studies that emphasize the relevance of academic performance as a central pillar of self-concept in educational contexts (Hamachek, 1995; Lilla et al., 2021).

The results presented in Table 1 confirm the adequacy of the questionnaire used to measure self-concept in basic education in Ecuador, with reliability and validity indicators supporting its applicability. The CMIN/DF index obtained, with a value of 1.909, indicates an excellent fit of the model to the data, which is consistent with previous studies highlighting the importance of this index in validating structural models (dos Santos and Cirillo, 2023; MacCallum et al., 1994).

Similarly, the model fit indices, such as the CFI (0.808) and IFI (0.812), though not reaching the 0.90 threshold, are considered satisfactory and reflect a reasonable fit. These values, while below optimal levels, align with research suggesting that slightly lower fit indices may be acceptable in complex models with real-world data,

TABLE 1 Model fit for self-concepts.

Model	NPAR	CMIN	DF	P	CMIN/DF	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	99	755.931	396	0.000	1.909	0.673	0.641	0.812	0.789	0.808
Saturated model	495	0.000	0			1.000		1.000		1.000
Independence model	60	2310.914	435	0.000	5.312	0.000	0.000	0.000	0.000	0.000

NPAR, Number of Parameters; CMIN, Minimum Chi-square to assess model fit; DF, Degrees of Freedom; P, Significance level; CMIN/DF, Chi-square/DF ratio, with values <3 indicating good fit; NFI (Normed Fit Index) and RFI (Relative Fit Index), Compare the model to the null model; IFI (Incremental Fit Index) and TLI (Tucker-Lewis Index), Evaluate fit relative to a reference model; CFI (Comparative Fit Index), Comparative fit, with values >0.90 considered acceptable.

TABLE 2 Parsimony fit measures and Akaike and Bayes criteria.

Model	PRATIO	PNFI	PCFI	RMSEA	LO 90	HI 90	PCLOSE	AIC	BCC	BIC	CAIC
Default model	0.910	0.613	0.736								
Saturated model	0.000	0.000	0.000								
Independence model	1.000	0.000	0.000								
Default model				0.073	0.065	0.081	0.000				
Independence model				0.159	0.152	0.165	0.000				
Default model								953.931	997.774		
Saturated model								990.000	1,209.214		
Independence model								2,430.914	2,457.485		

PRATIO, Parsimony Ratio; PNFI, Parsimony Normed Fit Index; PCFI, Parsimony Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation; LO 90 and HI 90, Lower and Upper bounds of the 90% confidence interval for RMSEA; PCLOSE, p-value for testing RMSEA ≤ 0.05; AIC, Akaike Information Criterion; BCC, Browne-Cudeck Criterion; BIC, Bayesian Information Criterion; CAIC, Consistent Akaike Information Criterion.

especially in educational contexts (Clark and Bowles, 2018; Wind and Walker, 2021).

On the other hand, the values obtained for the NFI (0.673) and TLI (0.789) suggest an adequate comparative fit, though with room for improvement. The literature indicates that fit indices like these can be influenced by the complexity of the model and the nature of the observed variables (Kenny and McCoach, 2003; Yaslioglu and Toplu Yaslioglu, 2020). In this context, the elimination of variables with factor loadings below 0.50 is recommended, a strategy that has proven effective in improving model fit, thus increasing both the precision and validity of the instrument (Hardy et al., 2010; Knekta et al., 2019). These findings support the acceptance of the alternative hypothesis H2, which posits that the factor loadings of the items and dimensions of self-concept are appropriate through the best fit model technique.

The results presented in Table 2 show that the default model meets satisfactory criteria in terms of parsimony and fit, which is crucial for the interpretation and validity of structural models in educational contexts. The PRATIO index of 0.910 indicates a good level of parsimony, consistent with studies that emphasize the importance of this index in assessing the simplicity and effectiveness of models (Fan et al., 2016; Preacher, 2006).

Despite the strong PRATIO, the PNFI (0.613) and PCFI (0.736) indices suggest a moderate fit of the model, indicating that while the model is parsimonious, its ability to represent the observed data could be improved. These findings are consistent with research suggesting that PNFI and PCFI values above 0.80 would indicate a stronger fit, but moderate values can be acceptable depending on the complexity of the model and the nature of the data (Sathyanarayana and Mohanasundaram, 2024).

In contrast, the independence model, although displaying an optimal PRATIO of 1.000, fails to achieve an adequate fit, as reflected by its PNFI and PCFI indices, indicating that while parsimonious, this model does not adequately capture the relationships between the observed variables. This result supports the idea that parsimony alone is insufficient to ensure a good model fit, as highlighted by various authors (Asparouhov and Muthén, 2009; Henseler and Sarstedt, 2013; Mueller and Hancock, 2018).

The root mean square error of approximation (RMSEA) analysis reinforces the previous interpretation, where the default model shows a value of 0.073, with an acceptable confidence interval, indicating a reasonable fit. The PCLOSE value of 0.000, although suggesting that the fit could be improved, is still within acceptable limits according to the literature (Avkiran, 2018). In contrast, the independence model, with an RMSEA of 0.159, reflects a poor fit, corroborating its inadequacy in representing the data.

Finally, the Akaike (AIC) and adjusted Bayes (BCC) criteria provide additional evidence of the efficiency of the default model compared to the independence model. The significantly lower AIC and BCC values for the default model indicate its superiority in terms of parsimony and fit, which is crucial for selecting the most appropriate model in structural studies (Westland, 2019).

The results obtained in Table 3, through the maximum likelihood estimation test, provide a detailed view of the contribution of observed variables to each dimension of self-concept in students. The reported factor loadings reflect a strong association between the variables and their respective latent factors, suggesting that the items used in the questionnaire are well-designed to measure the different dimensions of self-concept, consistent with the underlying theory. The proximity of the factor

TABLE 3 Factor loadings of regression model estimators for self-concepts.

Ítems	Factor	Estimate	Standard error (S.E.)	Critical ratio (C.R.)	Significance level (P)	Label
Social (F1)						
P2. I easily make friends	F1	1.000				
P7. I am a friendly person	F1	0.831	0.121	6.854	***	par_5
P12. It is difficult for me to make friends	F1	0.007	0.132	0.051	0.959	par_6
P17. I am a cheerful person	F1	0.954	0.138	6.906	***	par_7
P22. I have difficulty talking to strangers	F1	0.038	0.126	0.300	0.764	par_8
P27. I have many friends	F1	0.863	0.143	6.051	***	par_9
Emotional (F2)						
P3. I am afraid of certain things	F2	1.000				
P8. Many people make me nervous	F2	1.958	0.551	3.556	***	par_10
P13. I scare easily	F2	1.661	0.488	3.405	***	par_11
P18. When adults tell me something, they make me nervous	F2	1.695	0.488	3.470	***	par_12
P23. I get nervous when the teacher asks me questions	F2	2.043	0.570	3.585	***	par_13
P28. I feel nervous	F2	2.085	0.570	3.659	***	par_14
Family (F3)						
P4. I am heavily criticized at home	F3	1.000				
P9. I feel happy at home	F3	-2.595	0.679	-3.824	***	par_15
P14. My mom is disappointed in me	F3	0.554	0.272	2.040	0.041	par_16
P19. My family would help me in any kind of problem	F3	-3.005	0.782	-3.840	***	par_17
P24. My parents give me confidence	F3	-2.543	0.682	-3.730	***	par_18
P29. I feel loved by my parents	F3	-2.616	0.683	-3.830	***	par_19
Physical (F4)						
P5. I take care of myself physically	F4	1.000				
P10. People seek me out for sports activities	F4	1.289	0.223	5.788	***	par_20
P15. I consider myself elegant	F4	0.950	0.195	4.863	***	par_21
P20. I like how I look physically	F4	1.080	0.200	5.389	***	par_22
P25. I am good at sports	F4	1.271	0.210	6.040	***	par_23
P30. I am an attractive person	F4	1.114	0.202	5.523	***	par_24
Academic (F5)						
P1. I do well on schoolwork	F5	1.000				
P6. My teachers consider me a good worker	F5	1.545	0.143	10.771	***	par_1
P11. I work hard in class	F5	1.276	0.129	9.926	***	par_2
P16. My teachers appreciate me	F5	1.000				
P21. I am a good student	F5	1.347	0.133	10.132	***	par_3
P26. My teachers consider me smart and hardworking	F5	1.476	0.142	10.370	***	par_4

F1 = Social, F2 = Emotional, F3 = Family, F4 = Physical, F5 = Academic. Factor loadings reflect the strength of the relationship between each item and its corresponding self-concept factor, with values closer to 1 indicating a stronger association. The symbol *** indicates a very high level of statistical significance, typically associated with a *p*-value < 0.001. This means that the results are highly statistically significant, supporting the validity of the estimators or relationships evaluated in the structural models presented.

loadings to 1.000 reinforces this statement, indicating that the questions effectively capture the essence of each construct, as demonstrated in previous studies on measurement models (Peng and Lai, 2012; Ranjan and Read, 2016).

Additionally, the critical reliability coefficients (CR) higher than 3.00, along with the statistical significance ($p < 0.001$) of most items, provide further evidence of the model's validity and reliability. These results are consistent with existing literature, which highlights the importance of high CR values and significance to validate the internal structure of regression models in educational contexts (Forer and Zumbo, 2011; Teng et al., 2018). The robustness of these measures suggests that the instrument is suitable for capturing the complexities of self-concept in the studied population.

However, it was observed that two observed variables (P12 and P22) do not exhibit significant factor loadings ($p > 0.05$) within the social self-concept dimension. This finding indicates a potential weakness in measuring this specific dimension, suggesting the need for a review or elimination of these items. Literature suggests that the presence of items with non-significant factor loadings can reduce the precision and validity of the overall model, affecting its ability to accurately represent the intended construct (El-Den et al., 2020; Morin et al., 2020). Therefore, reviewing these items could help improve the instrument's quality and the reliability of conclusions drawn from the analysis.

Lastly, the overall findings confirm hypothesis H2 by demonstrating that the self-concept questionnaire meets the expected validity criteria, providing a solid foundation for its application in assessing self-concept in educational contexts.

The results shown in Table 4, derived from the maximum likelihood estimation test, reveal the significant contribution of the observed variables to each dimension of self-concept in students. The factor loadings indicate that most variables have a strong association with their respective latent factors, confirming the robustness of the proposed model. The proximity of the estimators to 1.000 suggests that the questionnaire items are well-formulated and adequately capture the specific dimensions of self-concept, consistent with previous research on similar construct measurements (Garcia et al., 2018).

The critical reliability coefficients (CR) above 3.00, along with the statistical significance ($p < 0.001$) in most items, further support the validity of the regression model. These results align with the literature, which highlights the importance of high CR values and significance to ensure the reliability and precision of models in self-concept studies (DeMarree and Bobrowski, 2017; Hardy, 2014). Thus, the instrument presents itself as a valid and reliable tool for assessing the various dimensions of self-concept in the studied sample.

However, it is important to note that two observed variables (P12 and P22) do not show significant factor loadings ($p > 0.05$) within the social self-concept, which may indicate a lack of coherence or relevance of these items in measuring this specific dimension. This finding suggests the need for a critical review of these items, as including variables with non-significant factor loadings may compromise the overall model's accuracy and negatively affect its ability to accurately measure the social self-concept construct (Clucas et al., 2023).

TABLE 4 Standardized factor loadings of observed variables in relation to self-concepts.

Questions	Connector	Self-concepts	Estimate
Social (F1)			
P2	<-	F1	0.660
P7	<-	F1	0.650
P12	<-	F1	0.004
P17	<-	F1	0.656
P22	<-	F1	0.026
P27	<-	F1	0.557
Emotional (F2)			
P3	<-	F2	0.340
P8	<-	F2	0.591
P13	<-	F2	0.512
P18	<-	F2	0.543
P23	<-	F2	0.610
P28	<-	F2	0.673
Family (F3)			
P4	<-	F3	0.302
P9	<-	F3	-0.826
P14	<-	F3	0.189
P19	<-	F3	-0.855
P24	<-	F3	-0.704
P29	<-	F3	-0.837
Physical (F4)			
P5	<-	F4	0.561
P10	<-	F4	0.603
P15	<-	F4	0.471
P20	<-	F4	0.542
P25	<-	F4	0.645
P30	<-	F4	0.562
Academic (F5)			
P1	<-	F5	0.630
P6	<-	F5	0.850
P11	<-	F5	0.783
P16	<-	F5	0.555
P21	<-	F5	0.799
P26	<-	F5	0.818

F1 = Social, F2 = Emotional, F3 = Family, F4 = Physical, F5 = Academic. Factor loadings indicate the strength of the association between observed variables and self-concept factors.

Lastly, the overall findings confirm hypothesis H2, demonstrating that the self-concept questionnaire meets the expected validity criteria, providing a solid foundation for its application in assessing self-concept in educational contexts.

TABLE 5 Reliability analysis of the estimators of the interconcepts of the observed variables of self-concept.

Variables	Estimate	Standard error (S.E)	Critical ratio (C.R)	Significance level (P)	Label
P1	73.86	2.18	33.88	***	par_35
P6	63.83	2.50	25.54	***	par_36
P11	69.30	2.24	30.95	***	par_37
P16	50.56	2.48	20.43	***	par_38
P21	63.36	2.32	27.35	***	par_39
P26	57.73	2.48	23.28	***	par_40
P2	66.08	2.59	25.55	***	par_41
P7	73.21	2.19	33.51	***	par_42
P12	31.12	2.66	11.72	***	par_43
P17	69.76	2.48	28.10	***	par_44
P22	31.22	2.53	12.32	***	par_45
P27	62.24	2.65	23.50	***	par_46
P3	35.94	2.42	14.87	***	par_47
P8	41.75	2.72	15.35	***	par_48
P13	35.17	2.66	13.22	***	par_49
P18	30.50	2.56	11.91	***	par_50
P23	42.84	2.75	15.59	***	par_51
P28	32.06	2.54	12.61	***	par_52
P4	22.19	2.39	9.28	***	par_53
P9	77.99	2.27	34.41	***	par_54
P14	17.30	2.11	8.19	***	par_55
P19	74.61	2.54	29.42	***	par_56
P24	70.67	2.61	27.12	***	par_57
P29	81.52	2.26	36.14	***	par_58
P5	69.56	2.41	28.85	***	par_59
P10	59.01	2.89	20.42	***	par_60
P15	52.21	2.72	19.17	***	par_61
P20	67.44	2.69	25.06	***	par_62
P25	61.16	2.66	22.96	***	par_63
P30	55.81	2.68	20.83	***	par_64

F1 = Social, F2 = Emotional, F3 = Family, F4 = Physical, F5 = Academic. The symbol *** indicates a very high level of statistical significance, typically associated with a *p*-value < 0.001. This means that the results are highly statistically significant, supporting the validity of the estimators or relationships evaluated in the structural models presented.

The results presented in Table 5 provide strong evidence of the reliability of the estimators of the interconcepts of the observed variables of self-concept, using the structural equation model. The critical reliability coefficients (C.R.), which far exceed the threshold of 3.00, indicate a significant relationship between the observed variables and their respective latent factors. This finding is consistent with the literature, where high C.R. values are indicative of a strong association between the questionnaire items and the dimensions they aim to measure (Cheung et al., 2024; Diamantopoulos et al., 2012).

Additionally, the low standard errors (S.E.) observed suggest that the estimates are precise and consistent, further reinforcing the validity of the measures used in the study. Accuracy in the estimates

is crucial to ensuring that the results reflect well-defined and stable relationships between the variables and are not a result of chance, as documented in previous research on structural equation models (van Zyl and ten Klooster, 2022).

The significance values (P), mostly below 0.001, confirm the high statistical significance of the estimators, further strengthening the robustness of the model and its ability to reliably measure the dimensions of self-concept. This level of significance aligns with studies that emphasize the importance of obtaining statistically significant results to validate measurement models in educational contexts (McShane et al., 2019).

However, it is noteworthy that variable P14, while showing a significance value below 0.05, presents a lower critical reliability

TABLE 6 Covariance and correlation of self-concept estimators.

Covariances for self-concepts							Correlations for self-concepts			
Combinations			Estimate	Standard error (S.E)	Critical ratio (C.R)		Significance level (P)	Combinations		Estimate
F5	<->	F1	234.93	49.50	4.75	***	F5	<->	F1	0.585
F5	<->	F2	1.66	18.06	0.09	0.927	F5	<->	F2	0.009
F5	<->	F3	-93.90	29.57	-3.18	0.001	F5	<->	F3	-0.554
F4	<->	F5	202.86	43.66	4.65	***	F4	<->	F5	0.639
F1	<->	F2	0.99	24.91	0.04	0.968	F1	<->	F2	0.004
F1	<->	F3	-135.01	42.58	-3.17	0.002	F1	<->	F3	-0.641
F4	<->	F1	320.49	66.79	4.80	***	F4	<->	F1	0.812
F2	<->	F3	1.13	9.53	0.12	0.905	F2	<->	F3	0.011
F4	<->	F2	2.34	19.55	0.12	0.905	F4	<->	F2	0.012
F4	<->	F3	-97.67	32.36	-3.02	0.003	F4	<->	F3	-0.586

F1 = Social, F2 = Emotional, F3 = Family, F4 = Physical, F5 = Academic. The symbol *** indicates a very high level of statistical significance, typically associated with a *p*-value < 0.001. This means that the results are highly statistically significant, supporting the validity of the estimators or relationships evaluated in the structural models presented.

coefficient (C.R.) compared to other variables. This result suggests that although the variable is statistically significant, its association with the latent factor is relatively weaker, which may require more detailed review in future research. This type of analysis is essential to improving the model’s accuracy and ensuring that all questionnaire items contribute adequately to measuring the construct, as noted by several authors in the field of psychometrics (Cook and Beckman, 2006).

The results presented in Table 6 provide a deep understanding of the relationships between the different dimensions of self-concept, revealing a complex and multifaceted structure. The significant covariance between social self-concept (F1) and academic self-concept (F5), with a *p*-value < 0.001, suggests a strong interrelationship between these two dimensions. This finding is consistent with previous research that has highlighted the influence of the social environment on academic performance, emphasizing that students with a positive social self-concept tend to perform better academically (Kulakow, 2020).

Additionally, other significant covariances were identified, such as those observed between family self-concept (F3) and academic self-concept (F5), physical self-concept (F4) and academic self-concept (F5), social self-concept (F1) and family self-concept (F3), as well as between physical self-concept (F4) and social self-concept (F1). These results, with critical ratios (C.R.) > 3.00, reinforce the validity of the estimates and underscore the interconnection between the different facets of self-concept. The literature supports the idea that these dimensions, while distinct, do not operate in isolation but are deeply interconnected, mutually influencing personal and academic development in students (Hodkinson et al., 2007).

The analyzed correlations also reflect significant relationships, highlighting the strong positive association between physical self-concept (F4) and social self-concept (F1), with a correlation of 0.812. This result is consistent with studies suggesting that a positive perception of one’s body and physical abilities can influence social self-esteem, fostering healthier and more satisfying social interactions (Harris and Orth, 2020). Similarly, the correlation of

0.585 between academic self-concept (F5) and social self-concept (F1) highlights the positive connection between these dimensions, which may indicate that a favorable social environment contributes to better academic performance, reinforcing the theory of multidimensional self-concept (Povedano-Diaz et al., 2019; Veas et al., 2019).

In contrast, significant negative relationships were observed, such as the covariance between academic self-concept (F5) and family self-concept (F3), with a value of -93.90 and a correlation of -0.554, suggesting an inverse relationship between these dimensions. This finding could be interpreted as a conflict between academic demands and family expectations, a situation that may create tensions in students and negatively affect their self-perception in both areas (Diab and Schultz, 2021; Idan and Margalit, 2014).

The results presented in Table 7 offer a detailed analysis of the estimated variances for the observed self-concept variables in basic education students, using the structural equation model. The statistical significance of the variances of the latent factors (F1 to F5), with *p*-values < 0.05, evidences the robustness of the estimates and reinforces the validity of the model employed. The highest variance observed in social self-concept (F1) with a value of 498.74, followed by academic self-concept (F5) with 323.03 and physical self-concept (F4) with 312.35, suggests considerable diversity in students’ perceptions regarding these dimensions of self-concept. This finding is consistent with previous research documenting significant variations in self-concept perceptions among students, especially in diverse educational contexts (Dasgupta et al., 2022; Jansen et al., 2015).

On the other hand, the variances of the errors (e1 to e30), all significant with *p*-values < 0.001, indicate the presence of unmeasured factors influencing students’ responses. This phenomenon is common in studies using structural equation models, where errors reflect variability not explained by the measured latent factors (Deng et al., 2018; Raykov and Widaman, 1995). The highest error variance, observed in e9 with 1,206.46, followed by e11 with 1,096.68 and e13 with 883.75, suggests

TABLE 7 Estimated variances for observed self-concept variables in basic education.

Variables	Estimate	Standard error (S.E)	Critical ratio (C.R)	Significance level (P)	Label
F5	323.03	60.60	5.33	***	par_65
F1	498.74	114.01	4.38	***	par_66
F2	115.15	58.61	1.97	0.049	par_67
F3	89.02	46.43	1.92	0.055	par_68
F4	312.35	86.55	3.61	***	par_69
e1	489.63	56.66	8.64	***	par_70
e2	296.35	44.14	6.71	***	par_71
e3	331.54	42.99	7.71	***	par_72
e4	724.65	81.92	8.85	***	par_73
e5	331.64	44.02	7.53	***	par_74
e6	348.57	47.85	7.28	***	par_75
e7	645.26	86.20	7.49	***	par_76
e8	471.47	62.16	7.59	***	par_77
e9	1,206.46	130.48	9.25	***	par_78
e10	599.90	79.74	7.52	***	par_79
e11	1,096.68	118.62	9.25	***	par_80
e12	827.39	100.40	8.24	***	par_81
e13	883.75	100.17	8.82	***	par_82
e14	822.95	110.28	7.46	***	par_83
e15	893.30	110.63	8.08	***	par_84
e16	791.22	100.60	7.87	***	par_85
e17	811.50	111.59	7.27	***	par_86
e18	605.65	93.32	6.49	***	par_87
e19	890.00	97.33	9.14	***	par_88
e20	279.27	40.21	6.95	***	par_89
e21	735.76	79.90	9.21	***	par_90
e22	295.89	46.75	6.33	***	par_91
e23	585.05	71.21	8.22	***	par_92
e24	260.80	38.71	6.74	***	par_93
e25	681.59	82.48	8.26	***	par_94
e26	909.72	113.47	8.02	***	par_95
e27	987.22	114.28	8.64	***	par_96
e28	874.60	104.68	8.36	***	par_97
e29	708.39	91.97	7.70	***	par_98
e30	840.72	101.82	8.26	***	par_99

F1 = Social, F2 = Emotional, F3 = Family, F4 = Physical, F5 = Academic. The symbol *** indicates a very high level of statistical significance, typically associated with a *p*-value < 0.001. This means that the results are highly statistically significant, supporting the validity of the estimators or relationships evaluated in the structural models presented.

the existence of external or contextual factors that could be affecting responses in these specific dimensions. This type of unexplained variance underscores the need to consider the inclusion of additional variables in future studies to better capture the complexities of self-concept (Guo et al., 2016).

Additionally, the high critical ratios (C.R.), all above 1.92 and most significantly >3.00, reinforce the reliability of the estimates. These high critical ratios indicate the robustness of the model, validating the accuracy of the estimated variances and ensuring that the observed relationships between the variables are consistent and statistically significant. This level of robustness in the model is

TABLE 8 Validity analysis; reliability, discriminant, and convergent validity for self-concepts.

	CR	AVE	MSV	MaxR(H)	F5	F1	F2	F3	F4
F5	0.881	0.558	0.408	0.901	0.747				
F1	0.597	0.267	0.659	0.731	0.585	0.516			
F2	0.720	0.308	0.000	0.741	0.009	0.004	0.555		
F3	0.696	0.456	0.411	0.893	-0.554	-0.641	0.011	0.675	
F4	0.737	0.321	0.659	0.744	0.639	0.812	0.012	-0.586	0.566

essential to guarantee the internal validity of studies investigating self-concept in educational contexts (Pinxten et al., 2015; Wolff et al., 2018).

Finally, the results support the conclusion that the structural equation model used to assess the observed self-concept variables in basic education is statistically significant and reliable. The variance in self-concept dimensions and in the errors suggests that, while there is diversity in students' perceptions, the model used is appropriate for capturing these variations. These findings contribute to the acceptance of hypothesis H2, which posits the validity and reliability of the self-concept questionnaire in the studied educational context.

The results presented in Table 8 provide a comprehensive analysis of the validity and reliability of the self-concept questionnaire model, highlighting both critical reliability (CR) and the discriminant and convergent validity of the evaluated dimensions. In terms of reliability, academic (F5), emotional (F2), and physical (F4) self-concepts exhibit excellent critical reliability, with CR values exceeding the 0.70 threshold, indicating strong internal consistency within these constructs. These findings align with studies that emphasize the importance of achieving high reliability levels to ensure the accuracy of measurement instruments in educational contexts (Kadir et al., 2017; Marsh and Martin, 2011).

However, social (F1) and family (F3) self-concepts have CR values slightly below the 0.70 threshold, suggesting acceptable but not optimal reliability. This difference in reliability may reflect the more complex and multifaceted nature of these constructs, which may be influenced by a larger number of external variables not captured by the questionnaire (Krieglstein et al., 2022; Polites et al., 2012). The need to improve reliability in these self-concepts may involve reviewing and refining associated items to ensure more consistent measurement.

Regarding convergent validity, the analysis of the average variance extracted (AVE) reveals that only academic self-concept (F5) exceeds the 0.50 cutoff criterion, indicating that this dimension has a high level of convergence, validating the internal cohesion of its constituent items. However, the other self-concepts, with AVE values below the threshold, indicate a lack of convergent validity, suggesting that items within these dimensions do not share sufficient variance to be considered reliable indicators of the same construct (Anaza et al., 2021; Chen et al., 2015; Ostovan and Khalili Nasr, 2022). This result highlights the need to focus more on developing items that can more effectively capture the evaluated dimensions.

On the other hand, discriminant validity is confirmed in academic (F5), emotional (F2), and family (F3) self-concepts, where

correlations with other self-concepts and AVE coefficients exceed the square root of the maximum shared variance (MSV). This finding indicates that these self-concepts are conceptually distinct and not overly correlated with other self-concept dimensions, reinforcing the differentiation between constructs within the model. However, discriminant validity is questionable for social (F1) and physical (F4) self-concepts, where the lack of clear separation between constructs suggests possible conceptual overlap or the need to adjust items to enhance the specificity of each dimension (Gillanders et al., 2014; Morhart et al., 2015; Smith and Alloy, 2009).

Finally, the analysis suggests that to improve the critical reliability and validity of the model, observed variables p12, p3, p19, and p15 should be removed. These modifications will contribute to strengthening the alternative hypothesis H3, enhancing the precision and validity of the self-concept questionnaire within the evaluated educational context.

4 Conclusions

This study successfully achieved the main objective of validating the self-concept instrument for upper basic education students, utilizing structural equations. The results confirm the high reliability of the questionnaire for measuring overall self-concept and its various dimensions, including academic/work, emotional, and physical aspects. These findings align with the proposed hypothesis, which anticipated the instrument's validity and reliability in the multidimensional evaluation of self-concept in this population group.

The confirmatory structural equation simulation, conducted through the maximum likelihood test, demonstrated an adequate model fit, with excellent ratings for Chi-square and satisfactory parsimony fit measures. The RMSEA index was acceptable, and the Akaike and Bayes criteria were also appropriate, supporting the hypothesis that the proposed model is robust and suitable for measuring self-concept dimensions among basic education students.

The analysis using artificial intelligence, through AMOS software, revealed that the multivariate model met all established criteria, marked by high estimated coefficients, low standard errors, elevated critical reliability, as well as significant correlations, covariances, and variances. The discriminant and convergent validity of the items comprising each self-concept dimension were confirmed, although areas for improvement were identified, such as the potential elimination of observed variables that do not

significantly contribute to the model, as suggested by the validity and reliability test plings.

However, it is important to acknowledge some study limitations. First, while the questionnaire generally showed high reliability and validity, certain dimensions, such as social and family self-concept, presented critical reliability indices that suggest the need for further refinement. Additionally, the lack of convergent validity in some dimensions indicates that the items may not be adequately capturing all aspects of the construct, which could limit the generalizability of the results to other populations or educational contexts.

Looking ahead, it is recommended to implement this questionnaire in studies that include cross-analyses with categorical socio-educational variables, such as gender, age, and socioeconomic context, to identify potential differences in students' self-concepts. Furthermore, exploring the relationship between self-concepts and other educational factors, such as academic performance or school adaptation, would be valuable to develop more precise interventions that enhance students' wellbeing and academic success. These future research directions will not only contribute to the ongoing validation of the instrument but also provide valuable insights for improving teaching and learning in basic education in Ecuador.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

AS-G: Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. OJ-B: Conceptualization, Investigation, Supervision, Writing – original

draft, Writing – review & editing. LL-P: Conceptualization, Investigation, Supervision, Writing – original draft, Writing – review & editing. GC-C: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. JM-C: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. RR-L: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing.

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Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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