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PSYCHOMETRIC PROPERTIES OF AN INSTRUMENT TO MEASURE THE ALGEBRA PROFICIENCY OF STUDENT TEACHERS

PROPIEDADES PSICOMÉTRICAS DE UN INSTRUMENTO PARA MEDIR EL DOMINIO DEL ÁLGEBRA DE ESTUDIANTES EN FORMACIÓN DOCENTE

Oscar Ochoa Martínez
Universidad Pedagógica de Durango, Mexico
[chokar128@hotmail.com] [https://orcid.org/0000-0003-3330-9138]
Manuel Ortega Muñoz
Universidad Pedagógica de Durango, Mexico
[drmanuelortega@hotmail.com] [https://orcid.org/0000-0003-2087-5501]
Zaret Jazmín Hernández Soto
Universidad Pedagógica de Durango, Mexico
[hernandezsotozaret@gmail.com] [https://orcid.org/0000-0002-5369-9228]

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ABSTRACT

This research is a continuation of the instrumental study that consisted of designing an instrument to measure the algebra proficiency (IMDA) of Mexican students in teacher training. The first stage included application of the Delphi method, expert judgment, content validity test using the Hernandez-Nieto coefficient and piloting with 79 undergraduate students in pedagogy, which resulted in a KR-20 alpha reliability coefficient of 0.89 and excellent content validity. The present study was carried out with the objective of finding out if the IMDA is prepared for a larger scale project and was verified through two ways: a) Determination of the psychometric properties of reliability and content validity; the first through the KR-20 alpha coefficient and the second through item quality; b) Measurement of variability through the regression model. The sample consisted of 333 undergraduate students in public institutions of higher education in the state of Durango, Mexico. The results indicated the following: a) Reliability of the KR-20 alpha with a value of 0.84 and acceptable values in the statistical mean of the difficulty index (MIdif=0.59) and discrimination index (MIdisc=0.31); b) The R-squared coefficient of determination indicated that the proportion of variability of the dependent variable is significantly explained by all the independent variables in the regression model. It is concluded that the IMDA is reliable and has validity to generalize results in measuring the algebra proficiency of students in teacher training.

RESUMEN

Palabras clave:
formación docente, instrumentos de evaluación, psicometría.

Esta investigación es continuidad al estudio de carácter instrumental que consistió en diseñar un instrumento para medir el dominio del álgebra (IMDA) de estudiantes mexicanos en formación docente. La primera etapa incluyó aplicación del método Delphi, jueceo de expertos, prueba de validez de contenido mediante el coeficiente de Hernández-Nieto y piloteo con 79 estudiantes de licenciatura en pedagogía, el resultado arrojó un coeficiente de fiabilidad del alfa KR-20 de 0.89 y excelente validez de contenido. El presente estudio se realizó con el objetivo de conocer si el IMDA está preparado para un proyecto de mayor escala y se verificó mediante dos vías: a) Determinación de las propiedades psicométricas de fiabilidad y validez de contenido; la primera mediante el coeficiente alfa KR-20 y la segunda a través de la calidad del ítem; b) Medida de variabilidad a través del modelo de regresión. La muestra estuvo constituida por 333 estudiantes de licenciatura de instituciones públicas de educación superior del estado de Durango, México. Los resultados indicaron lo siguiente: a) Fiabilidad del alfa KR-20 con un valor de 0.84 y valores aceptables en la media estadística del índice de dificultad *(MIdif=0.59)* e índice de discriminación *(MIdisc=0.31);* b) El coeficiente de determinación R-cuadrado indicó que la proporción de variabilidad de la variable dependiente es explicada de manera significativa por todas las variables independientes del modelo de regresión. Se concluye que el IMDA es fiable y tiene validez para generalizar sus resultados.

Introduction

Mathematical thinking involves engaging in mathematical activities related to counting, measuring, representing, inferring, and modeling (Rodríguez-Álvarez and Duran-Llaro, 2023), and the results of these activities have an impact on an individual's development. Therefore, it is important for future teachers to develop the knowledge and skills to analyze and propose practices that promote students' learning of mathematics and the development of mathematical thinking—areas in which the use of algebra is fundamental.

In general, mathematical practice refers to mathematical creation and/or production and consists of promoting knowledge of formal mathematical language and its application; as Bueno and Vivanco (2023) note, formal languages are important tools for inference and discovery—fundamental aspects that can enable teachers to conduct mathematical proofs at any educational level.

The process of developing mathematical thinking and applying mathematics begins in preschool, where the use of mathematical language is important, even if it is not developed in a formal way; however, the learning achieved there will be essential for primary school students to correctly address the use and understanding of mathematical symbols. This idea is shared by Alsina (2015), who argues that at this educational level, mathematical proofs cannot be carried out, but emphasizes the importance of performing simple verifications

Students in teacher-training programs must have a solid grasp of early algebra as a means of fostering algebraic thinking in the early grades of elementary school (Pinto et al., 2023); recognizing this type of thinking as a way of thinking about and working with mathematical objects, relationships, and structures helps students understand and find meaning in mathematics. The practice of early algebra is facilitated when it is promoted through real-life situations that allow for reasoning and argumentation, leading children to understand mathematical properties, identify patterns, and represent relationships—aspects that enable them to make generalizations (Pincheira and Alsina, 2021).

The algebra content in the secondary school mathematics curriculum falls under the thematic area of "numbers, algebra, and variation," specifically the academic content on adding and subtracting algebraic expressions; this academic content is introduced in the first year of secondary school and is significant in subsequent school years.

Teaching algebra in secondary education is essential for students' academic and personal development; this subject provides essential tools for solving mathematical problems and fosters critical thinking and logic—skills that are necessary in everyday life and throughout their educational journey (Aguirre and Cerati, 2020). A solid grasp of algebra is a tool that helps students improve their academic performance and serves as a foundation for more advanced studies in science, technology, engineering, and mathematics; therefore, understanding the importance of teaching algebra at this stage is crucial for developing competent and analytical citizens.

In secondary education, it is common to conduct both formal and informal mathematical demonstrations, which include processes for identifying and analyzing errors in the use of algebra, particularly those related to the acquisition of algebraic language and the transition from arithmetic to algebra (Avila, 2016).

At the upper secondary education level, formal proofs become widespread, and this educational setting is a crucial stage for the development of algebra because, to a greater or lesser extent, this branch of the exact sciences is relevant and plays a significant role in the professional world (Márquez, 2019); indeed, it is undeniable that there is a close correlation between technological development in a society and the role of mathematics.

It is at this educational level that mathematics takes on greater importance (European University, 2023), because this is where the processes for high school admission and for admission to higher education become more formalized, given that this subject is part of the curriculum in a wide variety of undergraduate degree programs.

The study of mathematics in teacher-training institutions of higher education is important because students must acquire tools to promote the development of their mathematical skills and facilitate problem-solving. In this regard, Aké (2019) argues that teacher training should incorporate the study of situations that allow students to rethink notations and arithmetic operations in ways that differ from the typical approach; that is, to cultivate a new mode of arithmetic thinking in which the basic notions of algebra can be constructed.

The student body at teacher-training institutions consists of students who completed their high school studies at technical or humanities-focused schools, regardless of the type or format of their secondary education; these are students who should have a solid grasp of algebra, however, in practice it has been shown that a considerable number of these students have difficulties with both understanding and applying concepts in this area of mathematics (Craveri, 2009).

To address this problem, it is advisable to administer a diagnostic assessment to students in order to determine their level of proficiency in algebra. This involves carrying out systematic and reflective processes to gather quantitative and qualitative information about student learning, which can be achieved through the use of various assessment tools, including exams of different types and formats.

Regardless of educational level, learning algebra is important for students' personal development, because acquiring the necessary knowledge in the field of mathematics is essential for students to achieve intellectual and holistic development that is reflected in their academic life and daily routines.

In this regard, it is worth noting that elementary school teachers are the primary promoters of the learning and application of mathematical concepts; therefore, it is important that their training include professional development in this area of knowledge, as teacher-training institutions recognize the need and importance of strengthening mathematics education to help future teachers acquire the skills that will enable them to guide their students in learning this discipline (Pérez, 2022).

The importance and necessity of strengthening knowledge and practice in algebra instruction among pre-service teachers in a global context were highlighted in a study conducted in Ecuador by Curichumbi and Navarro (2025), who refer to the European University's role in its geographic region and in Latin America.

In the teaching-learning process across various disciplines or fields of study, teachers conduct assessment activities, whether to promote learning improvement or for accreditation purposes. In this regard, it is recognized that students exhibit deficiencies stemming from their teacher training; for this reason, it is advisable to heed the suggestion of Pires (2024), who emphasizes the need for educational institutions and policymakers to prioritize offering specific courses and workshops to improve teachers' assessment skills.

Generally, teachers emphasize an assessment process aimed at evaluating learning outcomes. This involves carrying out systematic and reflective processes to gather quantitative and qualitative information about student learning (Hamodi et al., 2015), an educational practice that can be achieved through the use of various assessment tools, including exams of different types and formats.

The information gathered through the aforementioned assessment tools must be analyzed with methodological rigor that allows for the identification of strengths and barriers faced by students at the beginning, during, and at the end of an educational process, with the aim of guiding efforts toward its improvement. In this regard, the authors Sepúlveda-Obreque et al. (2017) highlight the need to promote professional development and training for teachers on topics related to the assessment of learning and performance, as well as the use of assessment tools and their subsequent analysis to evaluate proficiency in mathematics and the development of mathematical thinking among students and teachers.

Based on the above observations, this research project is a continuation of a study whose first part involved designing an Instrument for Measuring Algebra Proficiency [IMDA] (Ochoa and Rivera, 2024) and was aimed at Mexican students in teacher training programs. The process of developing the IMDA followed the stages of the Delphi method and expert judgment, content validity testing using the Hernández-Nieto coefficient (Hernández-Nieto, 2002), and a pilot study involving 79 undergraduate education majors, during which it achieved a Kuder-Richardson alpha-20 reliability coefficient of 0.89.

The second part of the study, which is the focus of this research, was conducted with the overall objective of determining whether the IMDA is ready for a larger-scale project. This was assessed in two ways: a) Determination of the psychometric properties of reliability and content validity—the former using the Kuder-Richardson alpha-20 coefficient and the latter through item quality; and b) Measuring variability using the multiple linear regression method.

Method

This research was conducted using a quantitative methodological approach with an instrumental design, in accordance with Matos et al. (2025), the study is considered instrumental in nature, since it aimed to determine the psychometric properties of the IMDA.

Exhibition and Participants

The total sample consisted of 333 student teachers who were currently pursuing their bachelor's degrees at various public institutions of higher education in the state of Durango, Mexico. The main inclusion criterion for selecting the students who would complete the survey was to consider those who had recently completed a course in mathematics education or a related subject as part of their academic program.

Participants were selected using a non-probabilistic sampling method (Otzen and Manterola, 2017). The sample size was determined based on the criteria outlined by Roco et al. (2021), which involves having a minimum of five and a maximum of 10 subjects per item—the ideal number for administering an improved instrument.

Validation Tool and Process

In the first part of the study, the IMDA scale consisted of 30 items distributed across five dimensions (García et al. (2019), with the following structure: a) Dimension 1: Transition from Arithmetic to Algebra (PAA), with six items; b) Dimension 2: Reversibility of Thought (RP), with six items; c) Dimension 3: Pattern Identification (IP), with six items; d) Dimension 4: Generalization of Knowledge (GC), with six items; and e) Dimension 5:

Abstraction and Reflection in Mathematical Processes (ARPM), with six items. The IMDA can be found in the Appendices section (see Appendix 1).

The instrument was administered via the Google Forms platform, which allowed for standardized and accessible administration. Participants completed the survey individually, at a single time, and under controlled conditions to ensure that they responded independently and without external assistance. Prior to administering the questionnaire, clear instructions were provided regarding the purpose of the instrument and how to complete it, emphasizing the importance of answering honestly.

In addition, the confidentiality and anonymity of the responses were ensured, which fostered an atmosphere of trust and reduced potential biases in the information collected. This data collection technique is endorsed by the authors Núñez et al. (2024), which state the following: “The future prospects suggested by teachers point to the need to continue innovating in the design and implementation of online assessment tools, as well as to address inequities in access to educational technology” (p. 2715).

Data Analysis

The data processed during the research were organized and classified using an Excel spreadsheet and analyzed using the SPSS statistical software. The following tests were performed on the results obtained from the IMDA application: measures of central tendency, reliability testing, item quality testing, and variability testing using the multiple linear regression model.

Measures of Central Tendency

The measures of central tendency used in the analysis were the scores obtained on each dimension of the IMDA and the total score.

Reliability Test

The instrument's reliability was calculated using the Kuder-Richardson coefficient, specifically the KR20 formula, since this method is used to assess the internal consistency of a measure based on dichotomous data. The calculation used to determine this psychometric property is a formula that takes into account the variance of the item scores and is the dichotomous equivalent of the alpha coefficient (López et al., 2019).

Item Quality Testing

The quality of an item was measured based on the values of its difficulty index and discrimination index. These statistics are closely related; however, it is important to note the specific role of the discrimination index, since, according to Hurtado (2018), the determination of the standard discrimination value influences the interpretation of the quality of the performance test. To determine the difficulty and discrimination indices for the item, we used the method described by Backhoff and Rosas (2000); Table 1 shows the range of values for the difficulty and discrimination indices, which are used to assess the quality of the item.

Table 1
Classification and Interpretation of Difficulty and Discrimination Indices

Difficulty Index	Interpretation	discrimination index	Interpretation
Less than 0.24	Extremely difficult	Less than 0.00	Terrible
Between 0.25 and 0.44	Difficult	Less than 0.20	Inadequate
Between 0.45 and 0.75	Ideal	Between 0.21 and 0.24	Acceptable
Between 0.76 and 0.91	Easy	Between 0.24 and 0.34	Well
Greater than 0.91	Too easy	Greater than 0.35	Excellent

Note. Adapted from Muñoz et al. (2024)

IMDA Variability Measure

The regression model was used to determine the variability of the dependent variable's score relative to its statistical mean, while also assessing whether this variability is significantly explained by the independent variables included in the model.

This test is valid for the purposes of the study because the analysis is performed using composite variables derived from dichotomous items. The rationale for conducting this statistical test is that the IMDA is unidimensional, since its items are associated with a single latent construct—specifically, the domain of algebra—which allows the total score to be interpreted as a valid measure of that variable, thereby justifying the use of parametric regression analysis. "It is very important to have a unidimensional instrument, since for many people this will be an essential requirement for generating valid measures (Wright and Masters, 1982; Wright and Stone, 1998; as cited in Burga, 2006, p. 55)."

The regression model uses the coefficient of determination, R^2, as the primary measure of variability (Rodríguez and Salmerón, 2018). The variables involved in the process were the total and dimension-specific scores obtained by the participants on the IMDA. For the purposes of data analysis using the SPSS statistical software, these were coded as follows:

1) Scores obtained by participants on the IMDA (P_{IMDA}). According to the regression model, this variable corresponds to the dependent variable or response variable.
2) Scores obtained by participants in each of the IMDA dimensions, which were: a) Score on *Transition from Arithmetic to Algebra* (P_{PAA}); b) Score on *Reversibility of Thought* (P_{RP}); c) Score on *Pattern Recognition* (P_{IP}); d) Score on *Generalization of Knowledge* (P_{GC}) and; e) Score on *Abstraction and Reflection in Mathematical Processes* (P_{ARPM}). According to the regression model, these variables correspond to the independent variables or predictor variables.

To determine the relationship between these variables, a regression analysis was performed using the following regression model.

$$y = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_i x_i$$

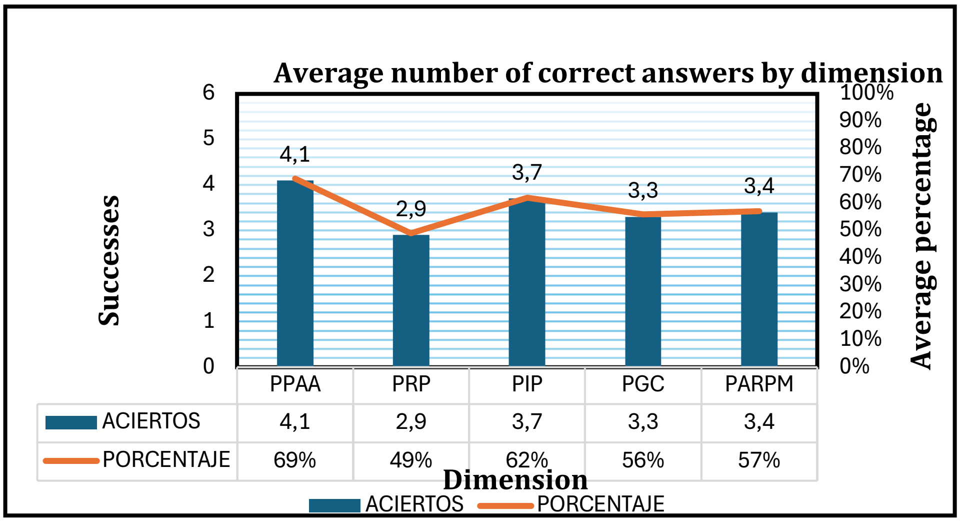
Results

Measures of Central Tendency

The graph in Figure 1 shows the statistical mean of correct answers recorded for each dimension of the IMDA; Here, it can be seen that there is a balanced score across dimensions, which is confirmed by the mean of the statistical means of correct answers *(*$M_{DIMENSIONS}$*=3.5)*

Figure 1

Average number of correct answers by IMDA dimension



The score obtained by participants on the IMDA *(P_{IMDA})* can be found in the appendix section (see Appendix 1). This data includes the mean score statistic P_{IMDA} (M_{IMDA}=17 correct answers). This value indicates that, on average, the 333 students answered 17 of the 30 IMDA items correctly.

Measure of Reliability

The reliability measure is shown in Table 2; the calculation was performed using the Kuder-Richardson alpha 20 formula, in accordance with Duran and Abad (2021). The coefficient value *(KR-20 = .846)* is good, since the authors consider it acceptable when it falls between .75 and .90.

Table 2

Reliability Test Results

Reliability Statistics	
Alfa 20 of Kuder-Richardson	Number of elements
.846	30

Validity of IMDA Content

Item Quality

Table 3 shows the difficulty index and discrimination index values for each item. It can be seen that all 30 items are considered to be of acceptable quality, since they fell within the preestablished quality range, Similarly, it can be seen that the statistical mean of the difficulty index (M_{Idif} = .59) is classified as having *adequate difficulty*, and the statistical mean of the discrimination index (M_{Idisc} = .31) is considered *good*, although both could be improved.

Table 3
Difficulty and Discrimination Indices

item	Idif	Idisc	item	Idif	Idisc	item	Idif	Idisc
1	0.49	0.31	11	0.48	0.33	21	0.52	0.35
2	0.68	0.38	12	0.52	0.38	22	0.61	0.36
3	0.77	0.26	13	0.59	0.38	23	0.50	0.24
4	0.70	0.27	14	0.43	0.40	24	0.59	0.30
5	0.77	0.27	15	0.63	0.34	25	0.64	0.33
6	0.72	0.34	16	0.70	0.26	26	0.61	0.31
7	0.44	0.37	17	0.60	0.22	27	0.47	0.43
8	0.63	0.34	18	0.78	0.29	28	0.41	0.21
9	0.49	0.36	19	0.66	0.20	29	0.59	0.21
10	0.38	0.35	20	0.47	0.22	30	0.69	0.31
							M_{Idif}=.59	M_{Idisc}=.31

Variability Test

Table 4 provides a summary of the regression model; the R-squared value for Model 1 indicates that the variability in the independent variable P_{IP}explains 64.2% of the variability in the dependent variable P_{IMDA}. In the subsequent models, it can be observed that the value of the coefficient of determination (R-squared) increases with the gradual inclusion of the independent variables P_{PAA}, P_{ARPM}, P_{GC}, and P_{RP}, to the point where the explained variability contributed by these scores accounts for nearly 100% of the variability in the P_{IMDA} score. The degree of variability explained by all the variables is significant, as evidenced by the value of the Fisher-Snedecor (F) test statistic, which is acceptable in each model and has a significant p-value.

Table 4
Model Summary

Model Summary

Model	R	R squared	Adjusted R-squared	Standard error of the estimate	gl	F	Mr.
1	,801[a]	,642	,641	3,695	331	593,499	,000
2	,908[b]	,824	,823	2,594	330	773,031	,000
3	,951[c]	,905	,904	1,914	329	1,038,982	,000
4	,977[d]	,955	,955	1,315	328	1,742.881	,000
5	1,000[e]	1,000	1,000	,000		.	.

a. Predictors: (Constant), P_{IP}
b. Predictors: (Constant), P_{IP}, P_{PAA}
c. Predictors: (Constant), P_{IP}, P_{PAA}, P_{ARPM}
d. Predictors: (Constant), P_{IP}, P_{PAA}, P_{ARPM}, P_{GC}
e. Predictors: (Constant), P_{IP}, P_{PAA}, P_{ARPM}, P_{GC}, P_{RP}

A complementary result to the R-squared coefficient test is the collinearity diagnosis proposed by Salmerón and Rodríguez (2017). Table 5 shows that, in each regression model, the multicollinearity statistic *Tolerance* yielded values close to "1"; these values indicate low multicollinearity among the independent variables, a result that reaffirms their effect in the regression model.

Table 5

Colinearity Statistics

Excluded variables[a]						
Model		In beta	t	Mr.	Partial correlation	Colinearity Statistics Tolerance
1	P_{PAA}	,483[b]	18,485	,000	,713	,781
	P_{RP}	,502[b]	17,176	,000	,687	,671
	P_{GC}	,400[b]	12,750	,000	,574	,738
	P_{ARPM}	,466[b]	16,501	,000	,672	,747
2	P_{RP}	,350[c]	14,631	,000	,628	,565
	P_{GC}	,316[c]	14,918	,000	,635	,710
	P_{ARPM}	,345[c]	16,648	,000	,676	,674
3	P_{RP}	,299[d]	18,787	,000	,720	,552
	P_{GC}	,270[d]	19,207	,000	,728	,693
4	P_{RP}	,286[e]	.	.	1,000	,551

Another indicator of the absence of multicollinearity among the scores of the independent variables is the presence of moderate correlation and the absence of high correlation between pairs. Table 8 shows that the correlation values between pairs range from .386 to .574, that is, the condition established by Goode-Romero (2019) to demonstrate the absence of multicollinearity is met, which consists of excluding pairs of variables that indicate a correlation coefficient ($r > 0.6$).

Table 6

Correlation Between Pairs of Variables

Correlations						
		P_{PAA}	P_{RP}	P_{IP}	P_{GC}	P_{ARPM}
P_{PAA}	Pearson's correlation coefficient	1	,556**	,468**	,386**	,473**
	Mr. (bilateral)		,000	,000	,000	,000
	N	333	333	333	333	333
P_{RP}	Pearson's correlation coefficient	,556**	1	,574**	,392**	,471**
	Mr. (bilateral)	,000		,000	,000	,000
	N	333	333	333	333	333
P_{IP}	Pearson's correlation coefficient	,468**	,574**	1	,512**	,503**
	Mr. (bilateral)	,000	,000		,000	,000
	N	333	333	333	333	333
P_{GC}	Pearson's correlation coefficient	,386**	,392**	,512**	1	,411**
	Mr. (bilateral)	,000	,000	,000		,000
	N	333	333	333	333	333
P_{ARPM}	Pearson's correlation coefficient	,473**	,471**	,503**	,411**	1
	Mr. (bilateral)	,000	,000	,000	,000	
	N	333	333	333	333	333

Discussion and Conclusions

Regarding the results of the IMDA application, the measures of central tendency indicated that there is a balance among the statistical mean values for correct answers across the five dimensions—a situation that, at first glance, reflects homogeneity in the responses to the IMDA and is indicative of an adequate measure of the construct *algebra proficiency*.

In light of the objective set forth in this study, the IMDA was administered to 333 student teachers, and it was found that the reliability statistic continues to indicate a fairly acceptable value *(KR-20 = .84)*, just five hundredths below the value obtained in the pilot test *(KR-20 = .89)*; this result confirms that the IMDA exhibits good internal consistency among items and stability over time.

With regard to the quality of the items, it was found that each of the 30 items had acceptable values for their difficulty and discrimination indices, as they fell within the range established for items to be considered of good quality; the same was true for the set of items that had acceptable values for the statistical mean of their difficulty index (M_{diff} = *.59)* and in the statistical mean of their discrimination index (M_{diff} = *.31*); these results indicate that, in general, the IMDA items are moderately easy and distinguish between those who have mastered algebra and those who have not.

The test of variability conducted using the regression model indicated that the variability of the dependent variable was significantly explained by each of the independent variables, accounting for 100% of the variability. This result was supported by the R-squared value recorded for each model, as shown in the summary of the regression model. These results indicate whether the observed variability in the IMDA is systematic or random, a characteristic that contributes to obtaining reliable and consistent information—in this particular case, regarding the level of algebra proficiency among student teachers.

A result that complements the IMDA's measure of variability is the *Tolerance* collinearity diagnosis, which yielded values close to "1." The value of this statistic indicates low collinearity among the independent variables in the regression model, which means that the variables are not strongly correlated with one another and that each independent variable provides unique information about the dependent variable. Consequently, the regression model is more stable and the coefficients are more reliable—characteristics that improve the accuracy of the IMDA estimates. Based on the results of the colinearity test, a correlation test was conducted between pairs of independent variables, and a moderate positive correlation was found for each pair.

Once the IMDA was subjected to rigorous studies involving a larger number of participants, it was confirmed that it possesses psychometric properties of reliability and content validity; furthermore, the results of the variability test indicated that the IMDA is also capable of detecting significant differences between individuals or groups.

These properties and psychometric characteristics exhibited by the IMDA enhance the robustness and generalizability of the results, ensuring that the instrument is accurate and useful for application in teacher-training populations where students with a wide range of proficiency in algebra come together, given that, at the bachelor's degree level, there are students who completed their high school education at technical and humanities-focused schools.

Through the implementation of the IMDA, the goal is to obtain a diagnostic assessment that will enable the implementation of targeted actions aimed at strengthening the development of mathematical thinking among student teachers, so that when they begin their teaching careers, they will have more and better tools to facilitate their students' learning and educational practice in this area of knowledge.

In order to expand the IMDA's utility, it still needs to be tested on populations with different educational levels, since care was taken in the formulation of its items to ensure their structure and level of complexity. Furthermore, there is also a need to conduct the test to determine whether it has predictive validity—a psychometric property through which students' success can be predicted.

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Appendices

Appendix 1

IMDA Score (P_{IMDA})

P	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A
1	30	**37**	26	**73**	23	**109**	21	**145**	18	**181**	16	**217**	14	**253**	12	**289**	11	**325**	9
2	30	**38**	26	**74**	23	**110**	21	**146**	18	**182**	16	**218**	14	**254**	12	**290**	11	**326**	8
3	30	**39**	26	**75**	23	**111**	21	**147**	18	**183**	16	**219**	14	**255**	12	**291**	11	**327**	8
4	30	**40**	26	**76**	23	**112**	20	**148**	17	**184**	16	**220**	14	**256**	12	**292**	11	**328**	8
5	30	**41**	26	**77**	23	**113**	20	**149**	17	**185**	16	**221**	14	**257**	12	**293**	10	**329**	8
6	30	**42**	26	**78**	23	**114**	20	**150**	17	**186**	16	**222**	14	**258**	12	**294**	10	**330**	8
7	30	**43**	26	**79**	23	**115**	20	**151**	17	**187**	15	**223**	14	**259**	12	**295**	10	**331**	8
8	29	**44**	26	**80**	23	**116**	20	**152**	17	**188**	15	**224**	14	**260**	12	**296**	10	**332**	8
9	29	**45**	26	**81**	23	**117**	20	**153**	17	**189**	15	**225**	14	**261**	12	**297**	10	**333**	7
10	29	**46**	26	**82**	23	**118**	20	**154**	17	**190**	15	**226**	14	**262**	12	**298**	10		
11	29	**47**	26	**83**	23	**119**	20	**155**	17	**191**	15	**227**	13	**263**	12	**299**	10	$M_{IMDA}=17$	
12	29	**48**	26	**84**	23	**120**	20	**156**	17	**192**	15	**228**	13	**264**	12	**300**	10		
13	29	**49**	25	**85**	22	**121**	20	**157**	17	**193**	15	**229**	13	**265**	11	**301**	10		
14	29	**50**	25	**86**	22	**122**	20	**158**	17	**194**	15	**230**	13	**266**	11	**302**	10		
15	29	**51**	25	**87**	22	**123**	19	**159**	17	**195**	15	**231**	13	**267**	11	**303**	10		
16	29	**52**	25	**88**	22	**124**	19	**160**	17	**196**	15	**232**	13	**268**	11	**304**	10		
17	29	**53**	25	**89**	22	**125**	19	**161**	17	**197**	15	**233**	13	**269**	11	**305**	10		
18	29	**54**	25	**90**	22	**126**	19	**162**	17	**198**	15	**234**	13	**270**	11	**306**	10		
19	28	**55**	25	**91**	22	**127**	19	**163**	17	**199**	15	**235**	13	**271**	11	**307**	10		
20	28	**56**	25	**92**	22	**128**	19	**164**	17	**200**	15	**236**	13	**272**	11	**308**	10		
21	28	**57**	25	**93**	22	**129**	19	**165**	17	**201**	15	**237**	13	**273**	11	**309**	10		
22	28	**58**	25	**94**	22	**130**	19	**166**	16	**202**	15	**238**	13	**274**	11	**310**	10		
23	28	**59**	25	**95**	22	**131**	19	**167**	16	**203**	15	**239**	13	**275**	11	**311**	10		
24	28	**60**	25	**96**	22	**132**	19	**168**	16	**204**	15	**240**	13	**276**	11	**312**	10		
25	28	**61**	24	**97**	22	**133**	19	**169**	16	**205**	15	**241**	13	**277**	11	**313**	10		
26	28	**62**	24	**98**	22	**134**	19	**170**	16	**206**	15	**242**	13	**278**	11	**314**	10		
27	27	**63**	24	**99**	21	**135**	19	**171**	16	**207**	14	**243**	12	**279**	11	**315**	10		
28	27	**64**	24	**100**	21	**136**	19	**172**	16	**208**	14	**244**	12	**280**	11	**316**	10		
29	27	**65**	24	**101**	21	**137**	18	**173**	16	**209**	14	**245**	12	**281**	11	**317**	10		
30	27	**66**	24	**102**	21	**138**	18	**174**	16	**210**	14	**246**	12	**282**	11	**318**	9		
31	27	**67**	24	**103**	21	**139**	18	**175**	16	**211**	14	**247**	12	**283**	11	**319**	9		
32	27	**68**	24	**104**	21	**140**	18	**176**	16	**212**	14	**248**	12	**284**	11	**320**	9		
33	27	**69**	24	**105**	21	**141**	18	**177**	16	**213**	14	**249**	12	**285**	11	**321**	9		
34	27	**70**	24	**106**	21	**142**	18	**178**	16	**214**	14	**250**	12	**286**	11	**322**	9		
35	27	**71**	23	**107**	21	**143**	18	**179**	16	**215**	14	**251**	12	**287**	11	**323**	9		
36	27	**72**	23	**108**	21	144	18	**180**	16	**216**	14	**252**	12	**288**	11	**324**	9		

Appendix 2

IMDA Tool

Items No	Item
1–6 (PAA)	Find the value of the algebraic expression: $2x + 3y =$ (for $x = 1$; $y = -2$)
	Find the value of the algebraic expression: $3a - 2b =$ (for $a = \frac{3}{5}$; $b = \frac{1}{10}$)
	Find the value of "x" in the algebraic expression: $x = 8 + y$; Consider that: $y = 4$
	Find the value of "x" in the algebraic expression: $8x - 8 = 6$.
	Enter the value of "x" to make the following algebraic expression equal: $-11 + 7 = x - 6$
	Find the equivalent of the following algebraic expression: $4(x - 2) + 6 =$
7–12 (RP)	Select the number that satisfies the equation: $(a)(b + c) = (ab + ac)$
	Find the value of "x" in the following algebraic expression: $\frac{3x}{4} - 12 = 0$
	On Equality: $r^4 = 256$ Which expression determines the value of "r"?
	Enter the result of the algebraic sum: $4x(y - 4xy) + 12x^2y =$
	Identify the factors of the quadratic trinomial: $x^2 - 3x - 18$
	Find the solutions to the system of simultaneous equations: $(2x + 4y = 28)$; $(-4x + 2y = -6)$
13–18 (IP)	Identify the term in the fifth position of the following geometric sequence: 3, 9, 27,…, (…),
	Identify the pattern in the following geometric sequence: 7, 11, 15, 19, …
	The sum of 6 consecutive numbers is 45. What should the range of these numbers be?
	What is the sum of the first 5 terms of the arithmetic progression: 15, 13, 11, …, …?
	Which geometric progression does the following pattern correspond to: $3n^2 - 2$
	Which monomial fits in the fifth position of the geometric sequence: $2xy, 4xy^2, 8xy^3, \ldots, (\ldots)$?
19–24 (GC)	State the equation that provides the solution to a direct proportion problem.
	State the equality that the solution to the inverse proportion problem yields.
	From the formula $R = \frac{V}{I}$, state the appropriate equation for calculating the value of (I).
	Derived from the formula: $x = \frac{4}{(y+z)}$, Provide the appropriate equation to calculate the value of "y".
	From the formula $°C = \frac{°F-32}{1.8}$; write the equation to find the temperature at $°F$
	Write the formula for finding the height (h) of a trapezoid: $A = \frac{(B+b)h}{2}$
25–30 (ARPM)	Write the mathematical model to represent: María's (M) money plus a quarter of Lupe's (L)
	Write the mathematical model to represent: Luis (L) has 8 fewer coins than Paco (P)
	Write the mathematical model to represent: Juan has 15 more coins than Pedro
	Write the mathematical model to represent the following: Writer "B" wrote 2.5 times as many pages as "A."
	Write the mathematical model to represent: There are 27 students in a group, and the number of women (W) is twice the number of men (M).
	Write the mathematical model to obtain an odd number.