

EXPLORATORY FACTOR ANALYSIS FOR THE VALIDITY OF MATHEMATICS LEARNING INDEPENDENCE INSTRUMENTS FOR ELEMENTARY SCHOOL STUDENTS

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ABSTRACT

This study aims to test the validity of elementary school students' mathematics learning independence instrument using Exploratory Factor Analysis (EFA). The research method used is a quantitative approach with factor analysis techniques to identify the latent structure of the instrument. Data was collected through a 73 grade V elementary school students questionnaire and analyzed using Kaiser-Meyer-Olkin (KMO), Bartlett's Test, and factor extraction with Principal Component Analysis (PCA). The study results show that this instrument has five main factors that significantly correlate with mathematics learning independence. The model match index shows good values, with RMSEA = 0.00 and TLI = 1.1705, signifying that this instrument is valid and reliable. However, some items with a loading factor below 0.40 and a high uniqueness (u^2) value were found, indicating that the items did not fully represent the measured factor. Therefore, it is necessary to revise or eliminate items with high cross-loading and add more specific items according to the dimension of mathematics learning independence. Thus, the developed instruments can be used in research and educational practice to measure the autonomy of elementary school students' mathematics learning while still paying attention to the improvement of the instrument in advanced studies.

Keywords: Learning Independence, Instrument Validity, EFA

INTRODUCTION

Learning independence is one of the important factors in education that contributes to students' academic success (Ananda, 2019; Maimun & Bahtiar, 2023). Learning independence not only reflects the extent to which a student can manage his or her learning process independently but also how he or she develops effective strategies for understanding the subject matter (Khasanah & Lestari, 2021; Moh Ghoizi Eriyanto et al., 2021; Mulyono, 2021). In mathematics education in elementary schools (SD), learning independence has a crucial role. Mathematics subjects are often considered difficult by students because they demand deep conceptual understanding as well as complex problem-solving skills (Hasibuan & Dewi, 2024; Santosa et al., 2023). Therefore, students with high learning independence will be better able to overcome difficulties in mathematics learning.

Mathematics learning at the primary school level requires students to develop a variety of cognitive, affective, and metacognitive skills that can help them understand mathematical concepts independently (Triutami et al., 2024). Students who have a high level of learning independence tend to have better confidence in solving math problems, are able to find additional learning resources, and have a strong intrinsic motivation to understand the material. In contrast, students with low levels of learning independence often have difficulty understanding concepts, rely on the help of teachers or peers, and lack initiative in completing academic tasks (Dalas et al., 2020; Rizki et al., 2022; Siregar et al., 2023).

Given the importance of the role of learning independence in mathematics learning, a valid and reliable measurement instrument is needed to measure the extent to which elementary school students have adequate learning independence in the context of mathematics (Amaliyah et al., 2022; Desi Fitriani et al., 2022; Lei & Razali, 2021). This instrument must be able to identify various aspects of learning independence, such as self-regulation, intrinsic motivation, learning discipline, and student's ability to overcome academic challenges (Segal et al., 2023). However, various previous studies have found that many instruments have not been tested empirically using proper analysis techniques, so their validity is still questionable.

One of the methods that can be used to empirically test the validity of the instrument is Exploratory Factor Analysis (EFA). Exploratory factor analysis allows researchers to identify the latent structure of an instrument so that it can be known whether the items in the instrument measure the dimensions in question (Watkins, 2018). EFA also helps in determining whether an instrument has factors that fit the theory underlying it or whether modifications to the constructed being measured need to be made (Ghani et al., 2022; Goretzko & Bühner, 2020). Thus, applying EFA in validating elementary school students' mathematics learning independence instruments is an important step in ensuring that the developed instruments can be widely used in research and educational practice.

In recent years, many studies have highlighted the importance of learning independence in improving student learning outcomes, especially in mathematics. However, most of the instruments used to measure the learning independence of elementary school students are still general and not specific to mathematics learning.

This is an obstacle for educators and researchers in understanding more deeply how learning independence contributes to understanding mathematical concepts at the elementary level.

In addition, many of the instruments used in previous research only relied on theoretical validation without conducting more in-depth empirical validation (Gomez et al., 2022). The theory's validity alone is insufficient to ensure that an instrument measures the desired construct. Therefore, applying Exploratory Factor Analysis (EFA) is important to identify the main factors underlying the construction of mathematics learning independence of elementary school students.

By conducting exploratory factor analysis, this research can significantly contribute to the field of psychometric measurement, especially in developing more accurate and reliable instruments for measuring the independence of mathematics learning of elementary school students. This study's results can benefit various parties, including teachers, researchers, and education policymakers, by helping them design more effective learning strategies based on empirical data.

The purpose of this study is to test the validity of the instrument to measure the independence of elementary school students' mathematics learning based on exploratory factor analysis (EFA) and evaluate the extent to which each item in the instrument has a strong correlation with the main factors that form the independence of elementary school students' mathematics learning. The validity test of the construct of the mathematics learning independence instrument for elementary school students was carried out to ensure that the instrument can be widely used in research and educational practice (Gomez et al., 2022). Thus, this research can contribute to developing psychometric instruments in mathematics education, especially in measuring elementary school students' learning independence. This research is limited to the development and validation of mathematics learning independence instruments for elementary school students using the Exploratory Factor Analysis (EFA) approach, with the main focus of this study is the analysis of exploratory factors.

LITERATURE REVIEW

Learning independence has become a significant research topic in education, especially related to mathematics learning outcomes in elementary school students. Learning independence significantly influences students' mathematics learning outcomes in online learning. The higher the learning independence, the better the learning outcomes (Septiani Utami et al., 2021). A study involving students of class XI of social studies at Xaverius Pringsewu High School found that students with a higher level of learning independence tended to be more active in completing assignments and achieving better academic grades. Linear regression analysis in this study revealed that learning independence had a significant influence with a significance value of $p < 0.05$, which showed that this factor played an important role in student's academic success. In addition, this study also revealed that in addition to learning independence, other factors such as the use of learning media, creativity, and emotional intelligence also contribute to improving student learning achievement (Tamara et al., 2019).

In a study conducted by Siagian et al. (2020), also explained that there was a significant influence between learning independence on the mathematics learning outcomes of grade V students at SD Negeri Padang Lais, with a t_{hitung} score of 2.029, which was more significant than t_{tabel} 1.681, indicating that the increase in learning independence was directly proportional to the increase in mathematics learning outcomes. In addition, research conducted by Maulana & Suryadi (2019), found that learning independence has a positive influence on mathematics learning achievement. In addition, there is a correlation between learning independence and logical intelligence in mathematics learning achievement. This suggests that other factors may also play a role in determining math learning outcomes but learning independence remains an important component that cannot be ignored.

In a broader context, learning independence affects the learning outcomes of mathematics and other subjects. Research by Rachmasari et al. (2021) explains the relationship between learning independence and reflective thinking ability in solving mathematical problems. The results show that students with a high level of learning independence are more able to consistently go through various phases of reflective thinking. Students who have high learning independence show more incredible initiative

in solving math problems, have high motivation and are more confident in presenting their answers.

However, although various studies have highlighted the importance of learning independence, the instruments used to measure the learning independence of elementary school students in mathematics still need to be further validated. The application of Exploratory Factor Analysis (EFA) is important to identify the latent structure of the instrument and ensure that each item measures the dimension in question. EFA allows researchers to identify the latent structure of an instrument so that it can be known whether the items in the instrument measure the dimensions in question (Steiner & Grieder, 2020). The validity of the construct using EFA helps the researcher in determining whether an instrument has factors that are under the theory underlying it or whether modifications to the measured construct are necessary (Hariono, 2021; Nasidi et al., 2022). Thus, applying EFA to validate elementary school students' mathematics learning independence instruments is important in ensuring that the developed instruments can be widely used in research and educational practice.

Moreover, Sürücü et al. (2024) emphasize that EFA helps identify an instrument's factor structure and eliminates irrelevant or redundant items, thereby increasing its validity and reliability. This is important to ensure that the instrument used measures the intended construct accurately and consistently.

Recently, interest in developing more accurate instruments for measuring learning independence has increased. Research by Ghani et al. (2022), highlighting the importance of validating learning independence instruments through EFA to ensure they are appropriate to the local cultural and educational context. They found that some items in the instrument adapted from other cultures did not fit the local context, so modifications needed to be made to increase their validity. Hariono (2021), in his research to develop learning independence instruments for elementary school students and validate them using EFA. The results show that the instrument has a factor structure based on the underlying theory, with a loading factor value for each item of more than 0.5, indicating that the instrument is valid and reliable for measuring the learning independence of elementary school students.

However, some challenges remain despite efforts to develop and validate learning independence instruments. One major challenge is ensuring the instrument can be used

widely in various educational contexts, given the cultural differences and education systems in different countries (Putri et al., 2022). Learning independence has a crucial role in elementary school mathematics education. Students often consider mathematics subjects difficult because they demand a deep conceptual understanding and complex problem-solving skills. Therefore, students with high learning independence will be better able to overcome difficulties in mathematics learning.

Mathematics learning at the primary school level demands that students develop various cognitive, affective, and metacognitive skills to help them independently understand mathematical concepts. Students with a high level of learning independence tend to have better confidence in solving math problems, can find additional learning resources, and have a strong intrinsic motivation to understand the material.

METHODOLOGY

This study uses a quantitative approach with the Exploratory Factor Analysis (EFA) analysis method to test the validity of the construct of elementary school students' mathematics learning independence instrument. The research was conducted in several elementary schools in Central Lombok, Indonesia, which were selected using a purposive sampling technique based on the criteria of the availability of learning support facilities and the level of student participation in mathematics learning. Data was collected through a Likert scale questionnaire developed to measure the independence of elementary school students' mathematics learning, which includes several key indicators such as self-regulation, intrinsic motivation, learning discipline, and mathematical problem-solving strategies. Three mathematics education experts tested this instrument for validity before its distribution. The questionnaire was given to 73 students in grade V of elementary school directly in the classroom.

Data analysis involves several stages. The Kaiser-Meyer-Olkin Test (KMO) and Bartlett's Test of Sphericity assess the adequacy of the sample and ensure that the data is feasible for factor analysis. Furthermore, Exploratory Factor Analysis (EFA) was carried out with Principal Component Analysis (PCA) to identify the structure of latent factors in the instrument. Varimax rotation was used to facilitate the interpretation of the formed factors and determine the distribution of indicators in the resulting factors.

RESULT AND DISCUSSION

1. Kaiser-Meyer-Olkin (KMO)

Before performing factor analysis, sample adequacy tests with Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were performed to ensure the data were eligible for factor analysis. The KMO test results show an overall MSA value of 0.52, which is below the ideal value (>0.60), but is still acceptable for further analysis with certain considerations. Meanwhile, the MSA values for each item varied between 0.43 and 0.62, indicating that some items had low sample adequacy and may need to be revised or removed. Thus, it is necessary to revise some items with low MSA or loading factors that do not meet the criteria. This revision may involve redrafting the item statement, removing irrelevant items, or adding new items that align with the measured concept.

2. Bartlett Test

This study used Bartlett's Test of Sphericity to evaluate whether the correlation matrix between items in the Mathematics Learning Independence instrument of Elementary School Students was feasible to be further analyzed using Exploratory Factor Analysis (EFA). This test determines whether there is a significant relationship between the variables tested so that factors that have conceptual significance can be formed in the constructed being studied.

The calculation results show that the Chi-Square value (χ^2) is 237.3518 with a degree of freedom (df) of 190 and a significance value (p-value) of 0.0111. The p-value obtained is less than the significance limit of $\alpha = 0.05$, which means there is a significant correlation between the items in this instrument so that factor analysis can be carried out.

The significance of the Bartlett test has important implications for the validity of the instrument; in this study, the results of Bartlett's Test indicate that the correlation between variables is strong enough to be further explored in the formation of latent factors underlying the independence of mathematics learning of elementary school students.

In addition to looking at the p-value, the magnitude of the Chi-Square value (χ^2) also gives an idea of the extent to which the data deviates from the identity matrix. The higher the Chi-Square value, the more likely a significant relationship between variables will be. In the results obtained, the value of $\chi^2 = 237.3518$ is relatively high, which further strengthens the evidence that this instrument has a correlation pattern that allows factor analysis to be carried out.

The Bartlett test in this study confirms that elementary school students' mathematics learning independence instrument has a fairly strong correlation structure, which allows for exploratory factor analysis (EFA). Thus, this study can continue to the next stage in identifying and validating the factors underlying the construct of learning independence in the context of mathematics learning in elementary schools.

3. PCA Analysis to View Eigenvalues

In validating the mathematics learning independence instrument of elementary school students, Principal Component Analysis (PCA) analysis is used to explore the structure of the underlying factors in the relationship between items in the instrument. The results of the PCA show that the eigenvalue of the first component is 1.972, which indicates that this factor has the most significant contribution in explaining the data variance. The second component has an eigenvalue of 1,531, followed by the third component of 1,420 and the fourth component of 1,379. An eigenvalue greater than 1 indicates that these factors have sufficient discriminatory power in forming the instrument's structure. However, after the fourth factor, the eigenvalue value decreases, with the fifth to tenth factors having smaller and smaller values, close to 0.8 or lower. This can also be seen in the scree plot image below.

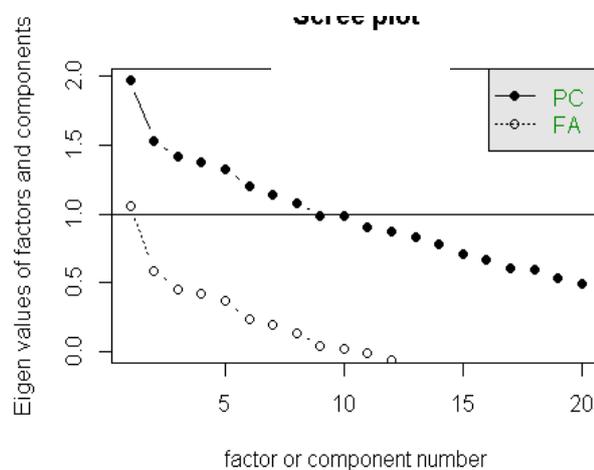


Figure 1. Scree Plot PCA Independence Learning Math

Figure 1 shows an elbow point on the fourth or fifth factor, indicating that the most suitable model consists of 4 main factors. The elbow point in the scree plot becomes the leading indicator in the PCA to determine the number of relevant factors because, after this point, the decline in eigenvalue becomes more sloping, indicating that the additional factors no longer contribute significantly to the total variance in the data.

4. Exploratory Factor Analysis (EFA)

This study carried out Exploratory Factor Analysis (EFA) to test the latent structure of the Mathematics Learning Independence instrument for elementary school students. The results of the analysis show that this instrument consists of five main factors, each representing a specific aspect of learning independence. This factor structure is identified based on the factor loading value, which shows how strong the relationship between an item and a certain factor is.

a. Results of Factor Analysis

Factor analysis was carried out to find out the comparison of the relationship between the question items in each factor formed. The results of the factor analysis carried out are as follows.

Table 1. Results of Analysis of Factors of Instrument Factors for Independence in Mathematics Learning for Elementary School Students

Item Interval	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	h ²	u ²	Complexity
Items 1 - 5	0.641	0.319	-	-	-	0.096 - 0.428	0.572 - 0.913	1.09 - 2.01
Item 6 - 10	0.396	0.442	-	-	-	0.031 - 0.228	0.772 - 0.969	1.24 - 2.57
Items 11 - 15	-	0.377	0.635	-	0.421	0.089 - 0.445	0.554 - 0.911	1.21 - 3.13
Items 16 - 20	0.365	-	0.304	0.519	0.421	0.127 - 0.292	0.707 - 0.873	1.17 - 2.40

Table 1 shows that the first factor shows a strong correlation with Items 1 to 5, with the loading factor value ranging from 0.641 to 0.319. This indicates that this factor reflects Self-Regulation in Learning, which describes how students can regulate and control their learning process. The items in this factor have an h² (commonality) value that ranges from 0.096 to 0.428, suggesting that most of the variability in these items can be explained by the factors that make up them. However, some items have relatively high u² (uniqueness) values, which means there is still variability not fully explained by this factor.

The second factor relates to Items 6 to 10, with the loading factor ranging from 0.396 to 0.442. This factor can be interpreted as Motivation for Learning Mathematics, which reflects students' intrinsic drive to understand mathematical concepts and solve learning challenges. However, some items in this factor have relatively low loading (<0.40), which suggests that some items may need to be revised or removed to clarify this factor in explaining student learning motivation.

The third factor strongly correlates with Items 11 to 15, with loading values ranging from 0.377 to 0.635. This factor describes Independence in Completing Assignments, which reflects how students can work on academic tasks independently without relying on external assistance. Several items in this factor also contributed to Factor 5, with a loading factor of 0.421, which indicates a possible relationship between independence in completing tasks and other factors related to students' attitudes and involvement in learning.

The fourth factor is closely related to Items 16 to 20, with the loading factor ranging from 0.365 to 0.519. This factor can be interpreted as Time Management and Learning Strategies, which reflects the extent to which students are able to plan, manage time, and use effective learning strategies to improve their mathematical understanding.

The fifth factor significantly contributes to some items in the Item groups 11 to 20, with the loading factor ranging from 0.304 to 0.421. This factor can be interpreted as Confidence in Learning Mathematics, which builds students' confidence in their ability to solve math problems independently.

To evaluate the extent to which each item contributes to the factors that make it up, two main indicators are commonality (h^2) and uniqueness (u^2). A high h^2 value (>0.40) indicates that an item has a strong relationship with the factors that form it. In contrast, a high u^2 value (>0.60) indicates that the identified factors cannot fully explain the variability of an item. In these results, some items have quite low h^2 values, especially in Factor 2 and Factor 4, which indicates the need for further study to refine the factor model.

The complexity of factors is also a consideration in this analysis. Complexity refers to the number of factors used to explain the variance of an item. A high complexity value indicates that an item is related to more than one factor, while a lower value indicates that the item is more specific to one particular factor. In the results of this analysis, the complexity of the factors ranged from 1.09 to 3.13, which indicates that some items are cross-loading, i.e. have a relationship with more than one factor. This cross-loading needs to be reviewed in further analysis to ensure the clarity of the resulting factor structure.

b. Factor Statistics

After identifying the factor structure of the Mathematics Learning Independence instrument for elementary school students, the factor statistics were analyzed to evaluate how each factor contributed to explaining the overall variance of the data obtained. The statistics

used in this analysis include SS Loadings (Sum of Squared Loadings), Proportion of Variance, and Cumulative Proportion, which provide an overview of how much each factor plays in explaining the measured construct.

Table 2. Statistical Results of Instrument Factors of Independence in Mathematics Learning for Elementary School Students

Factor Statistics	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
SS Loadings	0.860	0.838	0.757	0.736	0.635
Variance Proportions	0.043	0.042	0.038	0.037	0.032
Cumulative Proportion	0.043	0.085	0.123	0.160	0.191

Based on Table 2, Factor 1 has the highest SS Loadings value of 0.860, indicating that this factor contributes the most to explaining the data variance. The value of the variance proportion for Factor 1 is 0.043, which means that this factor can explain 4.3% of the total variance of the data. The cumulative proportion of variance from Factor 1 is 0.043, which means that up to this stage, only about 4.3% of the overall variance has been successfully explained by the first factor.

Furthermore, Factor 2 has an SS Loadings value of 0.838, slightly lower than Factor 1 but still quite significant. The proportion of variance explained by Factor 2 is 0.042 (4.2%). In comparison, the cumulative proportion increases to 0.085 (8.5%), indicating that by incorporating Factor 2 into the model, we managed to explain almost 8.5% of the variance from the existing data. This shows that Factor 2 also has a decisive role in explaining the independence of elementary school students in mathematics learning.

Factor 3 has an SS Loadings value of 0.757, which is lower than the first two factors but still has a sufficient contribution to the model. The proportion of variance from Factor 3 is 0.038 (3.8%), which means that this factor contributes to the additional data variance by 3.8%. After including Factor 3, the cumulative proportion becomes 0.123 (12.3%), which means that the first three factors together explain 12.3% of the total variance in the data.

Furthermore, Factor 4 has an SS Loadings value of 0.736, with a variance proportion of 0.037 (3.7%), so after incorporating Factor 4 into the model, its cumulative proportion increases to 0.160 (16.0%). Although this value shows a relatively small additional contribution compared to the previous factor, the existence of Factor 4 still has an important role in describing the dimension of mathematics learning independence.

Finally, Factor 5 has an SS Loadings of 0.635, with a proportion of variance of 0.032 (3.2%). Although its contribution is the lowest compared to the other four factors, Factor 5 still has a significant value in the structure of the model formed. By including Factor 5, the cumulative proportion increases to 0.191 (19.1%), which means that these five factors can only account for 19.1% of the total variance in the data.

These results show that although five factors have been identified, the ability of these factors to explain the variability of the data is still relatively low because the total variance described has not reached 50% of the total variance of the data. Ideally, in exploratory factor analysis, the factors formed can explain the more significant variance to show that the model obtained is sufficiently representative in describing the measured constructed.

The relatively small SS loading value and low proportion of variance indicate that the model still needs further revision. Some of the possible causes of low variance described are (1) the number of factors is still less than optimal, (2) some items have high cross-loading, or (3) some items have low discriminatory power against the factors formed. Therefore, further research must conduct a Confirmatory Factor Analysis (CFA) to evaluate whether the factors formed are under the underlying theory.

In addition, the number of variances explained by these five factors also indicates that other factors may not have been identified in this instrument. Therefore, in further instrument development, revisions can be made to many items or reductions to items with a low contribution to obtain a more precise factor structure and better explain the data's variance.

c. Model Fit Index

After conducting an exploratory factor analysis (EFA), the next step is to evaluate the model's fit to ensure that the structure of the factors obtained is under the empirical data. This evaluation was carried out using various model match indexes, which reflected how well the resulting model could explain the relationship between items in the Mathematics Learning Independence of Elementary School Students.

Table 3. Results of the Compatibility Index of the Mathematics Learning Independence Instrument Model for Elementary School Students

Model Fit Index	Value	Interpretation
Chi-Square Likelihood	92.6 ($p < 0.688$)	Shows a good model fit
RMSEA (90% CI)	0.00 (0.00 - 0.0297)	Very good model

Tucker Lewis Index (TLI)	1.1705	High factor reliability
Bayesian Information Criterion (BIC)	-442.586	Models are better than null models
Root Mean Square Residual (RMSR)	0.04	Residual minor errors

The results of the model match test in Table 3 show that the Chi-Square Likelihood value is 92.6 with a p-value < 0.688 , which indicates that the model has a good match. In the factor analysis, the insignificant Chi-Square test ($p > 0.05$) showed that the model did not differ significantly from the observed data, so it can be concluded that the factor structure obtained has a high degree of agreement with the analyzed data.

In addition, the Root Mean Square Error of Approximation (RMSEA) value obtained is 0.00 with a confidence interval range of 90% (0.00 - 0.0297). RMSEA is one of the most commonly used model match indexes, where a value of ≤ 0.05 indicates an excellent model fit. In the context of this study, the very low RMSEA value shows that the factor model formed does not contain large model errors and can optimally represent the data structure.

Furthermore, the Tucker-Lewis Index (TLI) has a value of 1.1705, which indicates a very high-reliability factor. TLI measures the increase in model fit compared to baseline models. A TLI value exceeding 1 indicates that the resulting model has an excellent fit level and can describe the relationship between variables with a high level of reliability.

The Bayesian Information Criterion (BIC) index is -442.586, indicating that the resulting model is better than the null model (without factor structure). In the model analysis, the smaller BIC showed that the model had a good balance between fit and complexity. In other words, this model is a good fit and is less complex, so it can be interpreted more easily.

Finally, the Root Mean Square Residual (RMSR) has a value of 0.04, indicating that this model's residual error is relatively small. RMSR measures the mean difference between the observed covariance matrix and the model-predicted covariance matrix. A smaller value indicates that the resulting model can predict the relationship between variables with minimal error rate, so this model has high validity.

Overall, the model match index analysis results show that the factor model formed matches the empirical data well. This is evidenced by insignificant Chi-Square values, very low RMSEA, high TLI, smaller BIC than null models, and low RMSR. Thus, it can be concluded that the Mathematics Learning Independence instrument for Elementary School Students developed through Exploratory Factor Analysis has a stable and valid factor structure.

d. Adequacy Score Factor

The adequacy analysis of factor scores evaluates the extent to which each factor identified in the Exploratory Factor Analysis (EFA) has a sufficient correlation with the factors produced and how the factor score explains the data variance. The three main metrics used in this analysis are correlation between factors, R^2 factor score, and minimum correlation, which provide insight into the quality of factor representation of the variables measured.

Table 4. Results of the Adequacy Score of the Instrument Factor of Independence in Learning Mathematics for Elementary School Students

Factor	Correlation with Factors	R^2 Score Factor	Minimum Correlation
Factor 1	0.742	0.551	0.101
Factor 2	0.709	0.503	0.006
Factor 3	0.700	0.490	-0.019
Factor 4	0.723	0.522	0.045
Factor 5	0.669	0.448	-0.105

Based on the analysis results in Table 4, factor 1 has a correlation of 0.742 with the resulting factors, which shows a strong relationship between this factor and the model structure formed. The R^2 value of the factor score is 0.551, which means that about 55.1% of the variance in the data can be explained by this factor. In addition, a minimum correlation value of 0.101 indicates that this factor still significantly contributes to the model. Thus, Factor 1 has a high degree of adequacy in explaining the dimension of mathematics learning independence of elementary school students.

Furthermore, Factor 2 correlates 0.709, indicating a relatively strong relationship with the factors in the model. An R^2 value of 0.503 indicates that this factor can explain 50.3% of the variance in the data, which means that this factor is still relatively stable and contributes well to explaining the structure formed. However, the minimum correlation value of only 0.006 indicates that some items may contribute less to this factor. Therefore, further analysis is needed to ensure this factor remains a strong interpretation.

Factor 3 correlates 0.700, with an R^2 value of 0.490, which means this factor can explain 49.0% of the data variance. This value is slightly lower than the first two factors but is still in the acceptable category in factor analysis. However, a minimum correlation value of -0.019 indicates that some items in this factor may negatively contribute to the structure of the factors formed. This negative correlation indicates that some items may fall short of the expected

dimensions, so further evaluation is needed to consider whether modifications or deletions of certain items are necessary for this factor.

For Factor 4, the correlation value with the factor in the model is 0.723, which indicates a relatively strong relationship. An R^2 value of 0.522 indicates that this factor can explain 52.2% of the variance in the data, so it can be said that this factor has a reasonably high level of reliability. A minimum correlation of 0.045 indicates no significant negative indications in this factor, so this factor is relatively stable and can be interpreted well in the model.

Finally, Factor 5 correlates 0.669, the lowest value among all factors, but still in the acceptable category. An R^2 value of 0.448 indicates that this factor can only explain 44.8% of the variance in the data, which is the lowest contribution compared to other factors. Furthermore, a minimum correlation value of -0.105 indicates a potential problem in this factor, where some items may not correspond to the dimensions formed. This sizable negative correlation may indicate that Factor 5 may have a problem in the item's fit or the factor's less stable structure.

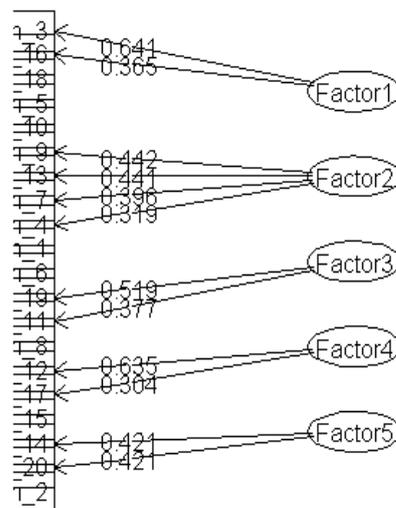


Figure 2. Factor Analysis

Figure 2 shows the results of a factor analysis that identifies five main factors from a set of variables. Each factor has several items that contain a specific factor loading value, which illustrates how strong the relationship between the item and the factor it represents.

Factor 1 has two main indicators with loading factors of 0.641 and 0.365, indicating that the first indicator has a stronger contribution than the second in explaining this factor. Factor 2 consists of four indicators with loading factors ranging from 0.319 to 0.442. Although the loading factor value is relatively small, this shows that there is a relationship between these items and the second factor.

Factor 3 only has two indicators with loading factor values of 0.519 and 0.377, indicating that the first indicator is more dominant in explaining this factor. Factor 4 consists of two indicators with loading factors of 0.635 and 0.304, with the first indicator contributing more. Finally, Factor 5 has two indicators with the same factor loading value, 0.421, which shows the balanced contribution of both indicators to this factor.

Overall, the results of this factor analysis show that the structure of the factors formed is quite clear with each factor having appropriate indicators. However, some low loading factor values (<0.4) may need to be reviewed further to ensure the suitability of items in this model. Further interpretation can be made by considering the significance of the factors formed and their relevance in the research context.

CONCLUSION

This study tests the validity of elementary school students' mathematics learning independence instrument using exploratory factor analysis (EFA). The results show that the developed instrument has five main factors with a factor loading value above 0.40, which indicates that each item has a strong relationship with the measured construct. The model match index showed good results with $RMSEA = 0.00$ and $TLI = 1.1705$, signalling that this instrument is valid. However, some items with high uniqueness (u^2) and significant cross-loading values need to be revised or deleted so that the instrument is more accurate in measuring the independence of elementary school students' mathematics learning. Thus, this research contributes to the development of instruments that can be used in research and educational practice, as well as opens up opportunities for further research to improve the quality of learning independence measurement in mathematics learning.

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