Validating Reading Literacy Instruments with EFA to Foster Joyful Learning

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ABSTRACT
This study aims to validate a reading literacy instrument for elementary school students and to examine its empirical construct using Exploratory Factor Analysis (EFA). A total of 320 fifth-grade students participated as respondents, completing a 30-item test developed from four theoretical indicators of reading comprehension: literal, inferential, critical, and reflective. Data analysis was performed using JASP. The Kaiser-Meyer-Olkin (KMO) value was 0.649 and Bartlett's Test of Sphericity was significant ($\chi^2 = 3858.287$; $df = 435$; $p < .001$), indicating that the data were suitable for factor analysis. The EFA revealed six empirical factors with a cumulative variance explained of 29.6%. Most items showed acceptable factor loadings (≥ 0.40), although five items had low measure of sampling adequacy (MSA < 0.50) and require revision. The six factors were interpreted as subdimensions of the four theoretical indicators, showing that reading literacy in elementary students is more complex than initially hypothesized. The validated instrument can assist teachers in mapping students' reading comprehension levels and in designing interactive, creative, and stress-free reading activities. Thus, the instrument contributes not only to reliable assessment but also to fostering joyful learning in the classroom.

Keywords: Reading Literacy, Exploratory Factor Analysis, Instrument Validation, Joyful Learning, Elementary Education.

1. INTRODUCTION

In the context of 21st century education, reading literacy is not only a basic skill that must be possessed by students, but also an important prerequisite for mastering various fields of knowledge to build critical thinking, reasoning, and problem-solving competencies independently [1]. Reading literacy at the elementary school level is the foundation of students in teaching and learning activities, accessing knowledge and understanding the surrounding world through written text. However, the results of the Indonesian National Assessment and the PIRLS and PISA International studies show that the reading literacy ability of Indonesian students is still below the global average, especially in the aspects of deep comprehension, critical evaluation, and reflection on the content of reading [2,3].

The low literacy score reflects the lack of optimal learning and assessment strategies applied in elementary schools. Most of the evaluation instruments used tend to only measure the literal aspect and do not reflect the complexity of the actual reading process. In fact, in the theory of reading comprehension developed by Barrett and further developed by Snow & Sweet, the reading process includes four main levels: literal, inferential, evaluative, and reflective [4]. The lack of instruments that are able to validly capture these dimensions results in the inhibition of mapping students' literacy skills in a complete and meaningful way.

On the other hand, the constructivist learning framework emphasizes that students need to be actively involved in learning processes that are cognitively challenging and relevant to their life context [5,6]. One of the strategies relevant to this principle is through the joyful learning approach, which is learning that is fun, interactive, and inspires students' curiosity [7]. Joyful learning is believed to be more effective if it is supported by well-designed assessments, which are instruments that are not only valid and reliable, but also able to direct teachers in developing learning interventions that are in accordance with students' ability levels. Evaluation instruments are needed that not only measure basic ability to understand the text, but also encourage students to interpret, evaluate, and reflect critically on the content of the reading.

One of the powerful statistical approaches to developing and validating instruments is Exploratory Factor Analysis (EFA). This analysis allows researchers to identify the latent structure of a set of indicators, as well as evaluate the extent to which the question items represent the theoretical construct being measured [8,9]. A number of previous studies have used EFA in the validation of literacy instruments, such as research by Putri & Rahmawati who developed a HOTS-based science literacy instrument [10], and research by Nugroho et al. who validated digital literacy instruments for junior high school students [11]. However, studies that specifically develop and validate reading literacy instruments for elementary school students by considering the four indicators of reading literacy (literal, inferential, evaluative, and reflective) are still very limited. This shows that there is a gap in the development of comprehensive instruments at the basic education level.

Another gap is that there are not many studies that integrate the results of instrument validation as the basis for the development of technology-based and fun learning media, such as Augmented Reality (AR). In fact, various studies show that the use of AR in learning can significantly increase learning motivation, student engagement, and conceptual understanding [12,13]. When valid literacy instruments are combined with interactive media such as AR, the learning process is not only joyful but also has a cognitive and affective impact on students.

This research offers a new approach by developing four reading literacy indicators and validating reading literacy instruments so that they can later be integrated into AR media to support fun learning in elementary schools. This approach not only answers the challenge of students' low reading literacy skills, but also answers the needs of innovative and contextual learning in the digital era.

Based on this background, this study aims to develop and validate reading literacy instruments for elementary school students using the EFA approach. This instrument measures four indicators of reading literacy (literal, inferential, evaluative, and reflective), and is designed to be integrated into AR-media-based learning. This study answers two main questions: (1) How is the validity of the construct of the reading literacy instrument based on the results of EFA? (2) How is the structure of the factors formed in accordance with the theoretical reading literacy indicator? Therefore, the purpose of this study is to explore and validate the construct structure of reading literacy instruments for elementary school students through the EFA approach.

The results of this study are expected to provide contributions in three important aspects, namely (1) theoretical contribution, through the provision of statistically tested reading literacy instruments; (2) practical contributions, in the form of support for teachers in conducting meaningful and fun reading literacy assessments: (3) innovative contributions, in developing data-based AR media to support a contextual and joyful literacy learning process. It is hoped that this article builds and connects between quality assessment and developing educational technologies to create a richer, more enjoyable, and impactful reading experience for Primary School students.

2. METHOD

This research is a quantitative research with an instrument development and validation approach. The main objective is to test the validity of the construct of the reading literacy instrument through the Exploratory Factor Analysis (EFA) technique. This approach was chosen to identify the latent factor structure of a series of indicators [8,9], especially in the initial process of instrument validation before entering the Confirmatory Factor Analysis (CFA) stage.

The subjects in this study are elementary school students in class V in the city of Pekanbaru, Riau. The sampling technique was carried out using purposive sampling, which is selecting students from schools that have implemented literacy-based learning. The number of samples used in this study was 320 students, which met the minimum sample size criteria for exploratory factor analysis. According to Hair et al. (2019) the ideal number of samples to perform an EFA is 5–10 times the number of items (30 items × 10 = 300 minimum).

The validated instrument consisted of 30 multiple-choice questions designed to measure reading literacy.

Table 1. Reading Literacy Ability Indicators

Yes	Indicators	Sub Indicators	Question No.
1	Literal	1. Finding the main idea 2. Finding cause-and-effect relationships 3. Finding the facts 4. Defining meaning	4, 5 12, 15 16 25, 29
2	Inferential	1. Conclude 2. Interpret 3. Join	1, 2 18, 19, 20 20, 26
3	Evaluative	1. Judge 2. Giving feedback	3, 6, 7, 8, 10 11 17, 25, 27
4	Reflective	1. Apply 2. Apply 3. Make	9, 13, 14, 20, 21, 22, 23, 24, 28, 30

Data analysis in this study used Exploratory Factor Analysis (EFA) with the help of JASP software (Version 0.18.2). The rotation technique used is Promax rotation because it is assumed that factors in reading literacy have an oblique rotation correlation. The data analysis steps include:

1. Feasibility test, using analysis:
   a. Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy: to see if the sample size is sufficient for EFA. The value of > SME 0.5 is declared feasible [15].
   b. Bartlett's Test of Sphericity: to test whether the correlation matrix between items is significant and factorable ($p < 0.05$).

2. Factor exploration
   The analysis was carried out with Principal Axis Factoring, determining the number of factors using criteria (Eigenvalue > 1; Scree Plot; The Proportion of Variance described), and items with a loading factor of ≥ 0.4 are considered valid.

3. Model evaluation
   The aim is to review the value of communality and uniqueness to see the contribution of each question item to the factor. In addition, model evaluation can also adjust the structure of the EFA outcome factors with theoretical indicators (literal, inferential, evaluative, reflective).

3. RESULTS AND DISCUSSION

3.1. Results

Validity of the reading literacy instrument construct based on the results of the EFA

This study aims to validate the construct of reading literacy instruments developed from four reading literacy indicators, namely literal, inferential, evaluative, and reflective. The following are the results of KMO research instruments that have been tested on 320 elementary school students in the city of Pekanbaru.

Table 1. Kaiser-Meyer-Olkin Test (KMO)

	MSA
MSA Everywhere	0.649
S1	0.448
S2	0.649
S3	0.690
S4	0.505
S30	0.547

Based on the EFA analysis carried out on 30 items of reading literacy, a KMO value of 0.649 was obtained, which means that this value indicates that the data is sufficient to be further analyzed using factor analysis. The value of Bartlett's test is significant of x2 = 3858.287, p <.001 which means that there is a correlation between items in the reading literacy test, so that the stages of extracting factors from the test items that have been developed can be continued.

Table 2. Bartlett's Test

X2	Df	p
3858.287	435.000	<.001

The results of factor extraction using the promax rotation method obtained six main factors with an eigenvalue of > 1, cumulatively able to explain 29.6% of the total variance in the reading literacy instrument. The results of the characteristics of the factors affecting the instrument can be seen in the following table.

Table 3. Factor Characteristics (Promax Rotation)

		Unrotated solution			Rotated solution		
	Eigenvalues	SumSq. Loadings	Proportion var.	Cumulative	SumSq. Loadings	Proportion var.	Cumulative
Factor 1	3.809	3.590	0.120	0.120	3.041	0.101	0.101
Factor 2	2.077	1.397	0.047	0.166	1.406	0.047	0.148
Factor 3	1.887	1.150	0.038	0.205	1.305	0.044	0.192
Factor 4	1.835	1.075	0.036	0.240	1.104	0.037	0.229
Factor 5	1.560	0.852	0.028	0.269	1.060	0.035	0.264
Factor 6	1.518	0.811	0.027	0.296	0.958	0.032	0.296

The first factor had the highest eigenvalue of 3,809 and accounted for 10.1% variance after rotation. Although the total contribution of variance has not yet reached the ideal figure (>50%), in educational instrument studies with many items, variance of around 30–40% is still acceptable especially if the factors formed are theoretically coherent. To see the loading factor of each question item, you can see the following table.

Table 4. Loading Factor of Reading Literacy Instrument

Subject	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Uniqueness
S3	0.965						0.005
S7	0.964						0.012
S14	0.962						0.019
S27		0.518					0.672
S18		0.461					0.573
S22		0.453					0.713
S26			0.468				0.744
S11			0.467				0.701
S25			0.405				0.668
S9				0.532			0.711

S20					0.511		0.606
S17					0.509		0.728
S23						0.487	0.743
S12						0.423	0.741

Most items show a loading factor above 0.4, which means they have a fairly strong contribution to the factor being formed. For example, items S3 (0.965), S7 (0.964), and S14 (0.962) show very high attachment to the first factor. These three items focus on evaluative skills, which are related to students' ability to give critical assessments of the text, such as comparing, assessing, or stating reasons for information in reading. The high loading indicates that the evaluative construct is strongly represented in the instrument.

Likewise, the second factor is inhabited by items such as S27 (0.518), S18 (0.461), and S22 (0.453), which are related to inferential ability. This aspect assesses the student's ability to draw conclusions from the implicit information in the text. The third factor is constructed by items such as S26 (0.468), S11 (0.467), and S25 (0.405) that correspond to literal indicators, i.e. direct understanding of explicit information in the reading.

The fourth to sixth factors consist of reflective items and a combination of several other indicators that have a fairly strong but relatively low loading rate (<0.6). Some items such as S20 (0.511) and S17 (0.509) were in the fifth factor, suggesting a tendency to group based on deeper reflective cognitive function, but could also reflect students' diverse interpretations of complex reading.

The structure of the factors formed is in accordance with the theoretical reading literacy indicators

The results of the EFA generally support the four theoretical indicators of reading literacy (literal, inferential, evaluative, and reflective). The relationship between the test items and the factors that make up the strength of the test can be seen in the figure below.

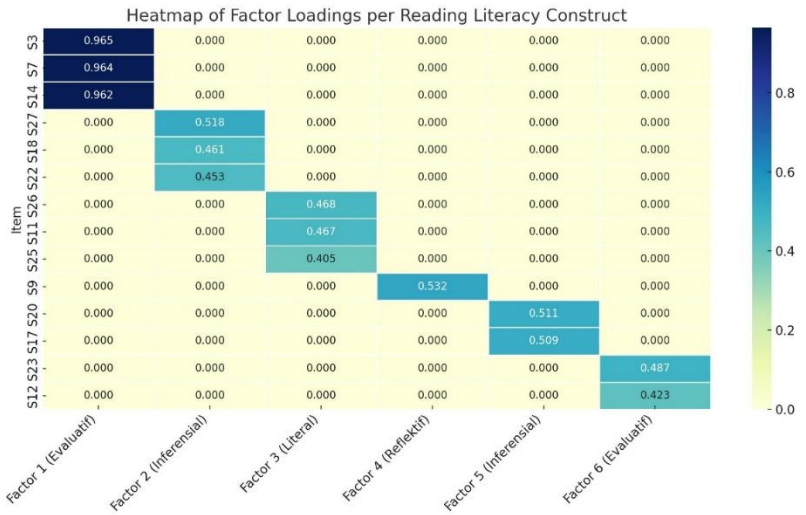

Figure 1. Heatmap loading factors reading literacy instruments

The structure of the factors formed from the EFA results suggests that most of the theoretical constructs referred to in the development of the instrument have been empirically confirmed, although not in a completely parallel structure. For example, evaluative indicators are not represented by just one single factor, but rather are spread across two factors (factors 1 and factor 6, indicated by items SS3, S7, S14, S23, and S12). This may reflect the complexity of a student's evaluative process that includes a variety of cognitive strategies, such as weighing the validity of information and assessing the credibility of sources, which in practice are not always integrated in a narrow dimension

Factor 2 and factor 5 reflect inferential abilities through items S18, S22, S20, and S17. Factor 3 describes literal ability. The 4-factor houses reflective items, such as S9. However, there is a regrouping of items from theoretical indicators to empirical factors that are not always linear. This is an important finding, indicating the potential for a reinterpretation of the item or revision of the language of the question to better represent the theoretical construct. Color gradation clarifies the item's contribution to a given factor, while making it easier to identify cross-loading or items that are not clearly associated with a single factor. These results are the basis for improving or rearranging reading literacy test items.

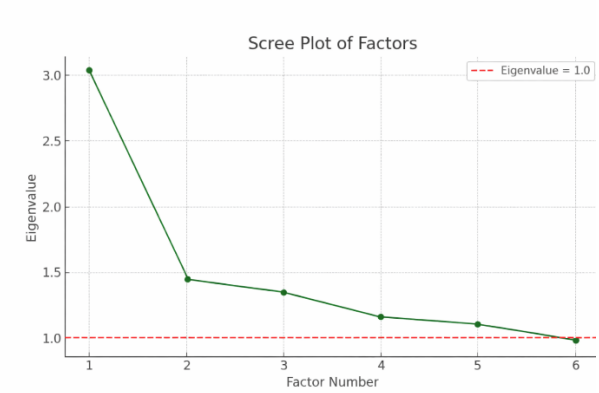

Figure 2. Validation Results Diagram

The diagram above shows the eigenvalues for the 6 factors of the rotation result. A dotted red line indicates Kaiser's limit (eigenvalue = 1). There is an elbow point in the 2nd to 3rd Factor, which means that the structure of the main factor can be conditioned into 3–4 main factors, resulting in a cumulative variance of 29.6%. This can be strengthened by theoretical rationale (4 indicators of reading literacy) and support from communalities.

The results of the EFA in this study identify that most of the reading literacy instrument items can be categorized into four main factors that are relatively in line with the theoretical indicators developed previously, namely literal, inferential, evaluative, and reflective. However, there were also a number of shifts in item classification that showed that students' cognitive structure in understanding reading was not always explicitly in line with theoretical categorization.

For example, items S11 and S8, which were originally developed to measure the evaluative aspect, turned out to be classified as literal factors in the EFA results. This indicates that students may still interpret the item at the level of explicit information instead of conducting a critical evaluation of the content of the reading. Similarly, the S4 item that theoretically measures literal comprehension is actually classified into empirically reflective factors, indicating that the item has succeeded in encouraging students to conduct deep reflection on the content of the text.

This tendency reinforces the importance of empirical validation through statistical approaches such as the EFA in testing the validity of instrument constructs, as instrument designs that are only based on theory do not necessarily reflect the actual responses of students. This is an important consideration in designing instruments that will be used to determine the influence and impact of Augmented Reality (AR) media, because the structure of valid factors greatly affects the effectiveness of technology-based assessments.

3.2. Discussion

Validity of the reading literacy instrument construct based on the results of the EFA

The results of exploratory factor analysis (EFA) show that the reading literacy instrument developed has adequate construct validity. This is evidenced by the SME value of 0.649 and the significant Bartlett's Test ($p < 0.001$), which indicates that the data is feasible to be factorially analyzed [16]. In general, a factor loading value of ≥ 0.4 has been met for items that are retained in the six main factors, although only four factors come close to the initial theoretical construct.

The validity of the construct is a fundamental requirement in the development of measurement instruments, because it ensures that the indicators tested do measure the aspects referred to in the theory [17]. In this context, the four constructs of reading literacy (literal, inferential, evaluative, and reflective) were empirically tested. From the results of the EFA, it can be concluded that most of the question items succeed in describing the structure of the construct in accordance with the theoretical framework, although there are some displacements or deviations of the items.

The move is not a negative thing, but reflects the complexity of elementary school students' cognitive processing in understanding reading. Items that were theoretically designed to measure reflective ability turned out to be empirically included in the literal factor, likely because the text and the choice of answers still did not sufficiently trigger deep metacognitive processes. These findings are in line with the opinion of Paris & Stahl, that reading skills are a layered process that takes time and experience to develop from the literal to the evaluative and reflective .

This study also emphasizes the importance of empirical validation of theoretical assumptions, because the validity of face and content alone is not enough to guarantee measurement accuracy. The validity of the construct provides an overview of the internal structure of the instrument, thus becoming a strong basis for use in formative and diagnostic assessments [19].

The structure of the factors formed is in accordance with the theoretical reading literacy indicators

The comparison between the structure of theoretical and empirical factors shows that there is a partial coherence that is interesting to analyze in depth. For example, all items in the "Evaluative" empirical factor (S3, S7, S14) consistently derive from the same theoretical construct, demonstrating good construct stability in this domain. This shows that students have the ability to make judgments about the content of the reading based on arguments or evidence from the text.

Nevertheless, some items move from the "Reflective" to "Literal" constructs, such as S4 and S2. This shift suggests that the reflective concept of reading, which demands deep understanding, critical evaluation, and integration with personal experience, is still not fully internalized in elementary grade V students. This is in line with the results of PIRLS, which shows that Indonesian students are generally still strong in literal comprehension but weak in interpretation and evaluation of texts [20].

Furthermore, inter-factor linkages were also seen in moderate communalities values (0.40–0.70) and eigenvalues > 1 in the initial six factors, suggesting that many items contained double loading, which could be interpreted as cognitive overlap between domains. This is in line with the multicomponent theory of Snow, which states that reading comprehension is an integrated process between decoding, inference, monitoring, and critical assessment [4].

The validation of the constructs that have been carried out in this study is not only important for the development of the instrument alone, but also a critical foundation in building an Augmented Reality (AR)-based learning system. When the instrument used has been psychometrically validated, the assessment data can be used accurately to: (1) Adapt reading content based on the student's literacy ability profile; (2) Directing the adaptive system on the AR platform to provide adaptive feedback; (3) Design a fun and personalized learning experience according to the student's domains of strengths and weaknesses.

This is in accordance with the findings of Bacca et al., who stated that AR significantly increases students' motivation and understanding because it provides an interactive and visual learning experience [13]. When valid literacy instruments are juxtaposed with responsive AR learning platform designs, there is a synergy between evaluation and intervention, which is able to create fun and meaningful learning

Limitations and Recommendations

Although the validity of the construct has been achieved, some items with low loading still need to be revised or eliminated in follow-up studies. In addition, it is recommended to follow the EFA with Confirmatory Factor Analysis (CFA) to test the suitability of the model more rigorously [14]. In addition, it is necessary to conduct internal reliability tests (e.g. Cronbach's Alpha or Composite Reliability) and discriminant analysis to corroborate the generalization of the results.

In the context of AR media development, it is necessary to conduct limited pilot testing to test the understanding, engagement, and effectiveness of this literacy instrument-based media before large-scale implementation.

4. CLOSURE

This study aims to explore and validate the construct of reading literacy instruments for elementary school students through the Exploratory Factor Analysis (EFA) approach. Based on the results of data analysis and interpretation, the following conclusions were obtained:

1. Construct Validity of Instruments Proven to be Feasible because Reading literacy instruments developed by referring to four reading literacy indicators (literal, inferential, evaluative, and reflective) have adequate construct validity based on the EFA test. Significant results of the KMO (0.649) and Bartlett's Test showed that the data were feasible to be factorually analyzed, while the six established empirical factors managed to explain most of the data variants statistically.
2. There is Correspondence and Deviation between Theoretical and Empirical Structures: The structure of the EFA outcome factors shows a partial coherence to the theoretical construction. Some items retain their original affiliation, such as evaluative domains that have been proven to be empirically consistent. However, there is also a deviation in which items move away from their theoretical constructs, indicating that students are not yet fully able to distinguish conceptually between literal and reflective understanding.
3. Ready-to-Use Instrument for Diagnostic Measurement: This validated instrument can be used as a diagnostic measurement tool to comprehensively map students' reading literacy skills, including explicit comprehension, inference, critical assessment, and reflection.
4. Potential Instruments to Be Integrated into AR Learning Media: The results of the construct validation open up opportunities for the integration of these instruments into Augmented Reality (AR)-based learning media, thus enabling personalization of learning based on authentic data from reading literacy test results.

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