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Practices and Challenges of the Validity of *Exploratory Factor Analysis* (EFA)-Based Assessment Instruments: A Systematic Literature Review 2020–2025

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ABSTRACT

The validity of assessment instruments is the basis for ensuring the quality of learning assessment. A valid instrument allows the results of the evaluation to be used appropriately in educational decision-making. This study aims to examine the practice of using *Exploratory Factor Analysis* (EFA) and identify common weaknesses in the validation of assessment instruments through *Systematic Literature Review* (SLR) based on the PRISMA guidelines. Articles were searched from the Scopus database of 2020–2025, with 30 selected articles out of 746 analyzed. The results show that EFA is widely used to explore the validity of constructs in cognitive, affective, and psychomotor assessments in the fields of education, psychology, social, and Islamic Religious Education. The EFA is effective in identifying the structure of latent factors in instruments that do not yet have a standard theoretical model. Some common challenges include difficulty determining the number of factors, confusion between EFA and PCA, and limitations in dealing with residual correlations. Recommended solutions include parallel analysis, fit indices, the use of ESEM, as well as improved methodological training. This study concludes that the appropriate use of EFA supports the development of instruments that are more valid and adaptive to the needs of today's educational assessments.

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1. INTRODUCTION

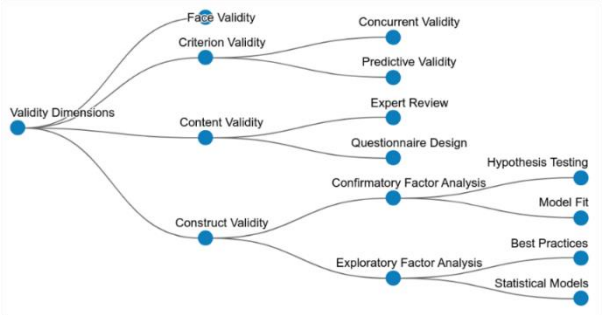
Assessment has an important role in education as a tool to measure student achievement, the basis for learning design, and the evaluation of teaching quality (Danielson, 2017; Sievertsen, 2025), and the formulation of education policies (Peppler et al., 2023; Sievertsen, 2025). Assessment instruments should ideally be authentic, objective, and comprehensive (Magdalena et al., 2023). that is to reflect the

real abilities of students (Maphosa et al., 2024; Peña et al., 2024). Deliver consistent results without subjective bias (Maharani et al., 2023), and covers the cognitive, affective, and psychomotor domains (Lukman et al., 2024; Noor et al., 2020). These three characteristics are in line with the demands of 21st century assessments that emphasize critical thinking competencies, creativity, collaboration, and communication (Ramadani et al., 2017). However, many assessment instruments in the field have not met the expected standards of validity (Bekoe, 2023; Malik & Priyadi, 2021; Teglasi et al., 2023). Low validity is often caused by unclear indicators, ambiguous questions, and mismatches between items and learning objectives (Nkwake, 2023; Septiana & Hermanto, 2024). The assessor's bias factor also reduces the objectivity and fairness of the assessment (Davis & Stahl, 2023; J. Wang et al., 2021). Especially if the instrument is compiled without adequate conceptual and empirical analysis (Firdianis et al., 2019; Nisa et al., 2023). In fact, the results of assessments are often used as the basis for important decisions in the education system.

The issue of the validity of assessment instruments is increasingly complex along with the dynamics of contemporary education, such as curriculum changes, shifts in learning models, and the use of digital technology in assessments (Saltos-Rivas et al., 2022; Viberg et al., 2024). Curriculum reform based on competencies and character demands more adaptive and contextual instruments (Jaramillo et al., 2024). While online learning and *Hybrid* Post-pandemic changes assessment patterns (X. Xia, 2024). Digital assessments offer efficiencies, but they also present new challenges, such as access gaps (Duong, 2024; Liou et al., 2022), academic integrity, as well as limitations in measuring non-cognitive skills (Swiecki et al., 2022). This condition demands a more systematic, innovative, and data-based approach to validation so that the instruments remain relevant, fair, and reliable in the midst of changing learning contexts (Teglasi et al., 2023).

Various solutions have been offered by experts to improve the validity of assessment instruments, including the development of modern validity theory-based instruments that include content validity (*Content validity*) (Ansari & Khan, 2023), construct (*construct validity*) (Tavakol & Wetzel, 2020), and criteria (*criterion-related validity*) (Saw et al., 2025), as well as the use of statistical techniques such as *Exploratory Factor Analysis* (EFA) (Sawiji et al., 2024), *Confirmatory Factor Analysis* (CFA) (Jones et al., 2022; Richter & Richter, 2024), and models *Rasch* (Sari et al., 2024; Surya et al., 2021) to Evaluate the internal structure and potential bias of the instrument (Conway, 2020). The integration of quantitative and qualitative methods such as interviews and expert reviews is also used to strengthen conceptual validity (Boone & Staver, 2020; Denovan et al., 2022). Instrument validation now also pays attention to the social context, language, and values of students (Baidoo-Anu et al., 2024; Ikhsanudin, 2023). and utilizing digital technology and artificial intelligence for a more adaptive and efficient validation process (Oktavianus et al., 2023; Saputra et al., 2024). This complexity demands innovation in the development of relevant assessment instruments in the 21st century (Ramadani et al., 2017). Considering that validity is the foundation of assessments that are not only technical, but also epistemological principles (Qizi, 2024; Sugiarta et al., 2024). EFA is an effective approach to test construct validity by empirically identifying latent structures (Abdullah et al., 2022; W. H. Finch, 2020; Jani et al., 2023). allows for more accurate grouping of items (Avşar, 2022; Prihono et al., 2022), and ensure the construct reflects the reality of the field (Dey & Roy, 2022; Jani et al., 2023; Ritchie & Sharpe, 2022). The position of the EFA in the validity dimension of the instrument can be illustrated in the following concept map.

Figure 1. Concept maps of *the position of Exploratory Factor Analysis* (EFA) in instrument validity



The concept maps shows that *Exploratory Factor Analysis* (EFA) is on the construct validity path, which is a validity that tests whether an item in an instrument actually measures a theoretical construct. The EFA serves as a first step to explore latent factor structures without the assumption of initial models, as well as related to *best practices* and *statistical models*, which affirm the need for appropriate statistical approaches to generate robust construct validation.

As attention grows to the importance of data-driven instrument validation, the use of *Exploratory Factor Analysis* (EFA) in instrument validation studies experienced significant growth. The practice of applying EFA in various studies shows that there is considerable variation, especially in technical aspects such as factor extraction methods (*Extraction methods*) (Auerswald & Moshagen, 2019), factor rotation technique (*Rotation Methods*) (Goretzko, 2023), as well as the criteria used (Lo et al., 2017).

This study makes an important contribution by presenting a systematic synthesis of best practices, common weaknesses, and trends in the use of *Exploratory Factor Analysis* (EFA) in the validation of assessment instruments, which were previously spread across various separate studies. The review critically identified frequent methodological errors, such as misdetermination of factor counts, misidentifications of EFAs and PCAs, and disregard of residual correlations, while developing a framework of procedural recommendations to help researchers apply EFAs accurately and consistently. With a focus on publication in 2020–2025, this study updates the understanding of EFA-based instrument validation practices in the post-pandemic era. The two main questions to be answered are how to practice using EFA in the validation of assessment instruments and what are the general weaknesses in its application. The results of this study provide comprehensive mapping as well as evidence-based guidelines to improve the quality of research in the field of instrument development. This study fills the literature gap through a structured, relevant, and reflective systematic study, and can be used as a reference for researchers who want to produce assessment instruments that are valid, contextual, and adaptive to today's educational needs.

2. METHODS

This study uses a qualitative approach with the *Systematic Literature Review* (SLR) method based on the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) guidelines to gain a comprehensive understanding of trends, methods, and study findings regarding the validation of *Exploratory Factor Analysis* (EFA)-based instruments in the 2020–2025 period. The main data source came from *Scopus-indexed* scientific articles, with the keyword "*Exploratory Factor Analysis*" which resulted in 746 articles. The literature search and mapping process is carried out through four systematic stages, namely identification, screening, content feasibility assessment, and inclusion. The selection of articles followed certain criteria that were adjusted to the focus of the study and the framework of the analysis, until 30 relevant articles were obtained for in-depth analysis. The inclusion and exclusion criteria can be described in the following table.

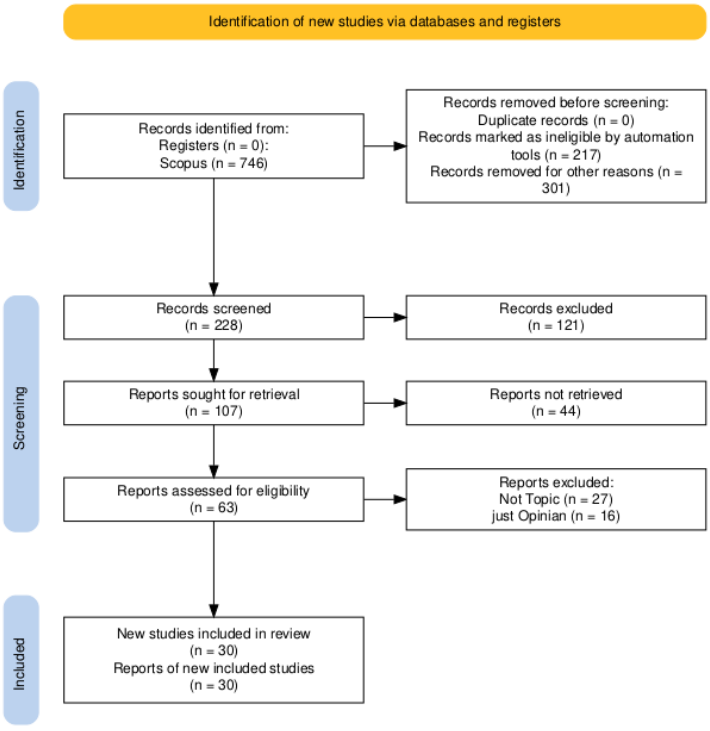
Table 1. Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Publication Period	2020-2025	Before 2020
Study Focus	Focus on the validity of assessment instruments in the context of learning (cognitive, affective, or psychomotor).	Articles that only discuss reliability without discussion of validity
Types of Research	Empirical research, Literature Review, Qualitative/quantitative studies	An opinion study
Source Type	Articles published in International Journals (*Scopus*)	Articles published in other than International Journals (*Scopus*)
Language	English	Other than English

Empirical research and publication criteria of the last five years were selected to ensure that the studies analyzed were current and relevant to the validity of the assessment instruments, and that the use of a single language allowed for more consistent analysis and comparison without the risk of differences in meaning due to language variations or translations.

The next step is to filter the article by title and abstract to ensure its fit with the keywords as well as the inclusion and exclusion criteria. Articles that pass this stage are downloaded in full version and re-evaluated to ensure their relevance to the research focus. Articles that meet the criteria are then selected for further analysis. This process is briefly illustrated through the following PRISMA flowchart.

Figure 2. PRISMA Flow Diagram



The image shows the flow of the article selection process in the *Systematic Literature Review* (SLR). A total of 746 articles were found through the *Scopus database*. A total of 518 articles were eliminated because the files were corrupted and did not meet the inclusion criteria. A total of 228 articles entered the screening stage based on titles and abstracts, and 121 of them were eliminated. A total of 107 articles were continued to the review stage, and 44 were not successfully accessed. At the eligibility assessment stage, 63 articles were thoroughly analyzed. A total of 43 articles did not meet the criteria because they were not on topic or were only opinions. A total of 30 articles remained and were used as analytical materials in this study.

3. FINDINGS AND DISCUSSION

Article Mapping on Exploratory Factor Analysis (EFA)

From the results of a search in the *Scopus database* with the keyword "*Exploratory Factor Analysis*," 746 articles were identified. After being selected using the PRISMA flow, 30 articles met the inclusion criteria. The mapping of the selected articles was carried out based on attributes such as author name, year of publication, journal information (name, volume, edition, year), type of publication, *Scopus ranking*, and its relevance to research questions related to use practices and general weaknesses of EFA in the validation of assessment instruments. The following graph shows articles that meet the inclusion criteria:

Figure 2. Mapping of articles that meet the inclusion criteria

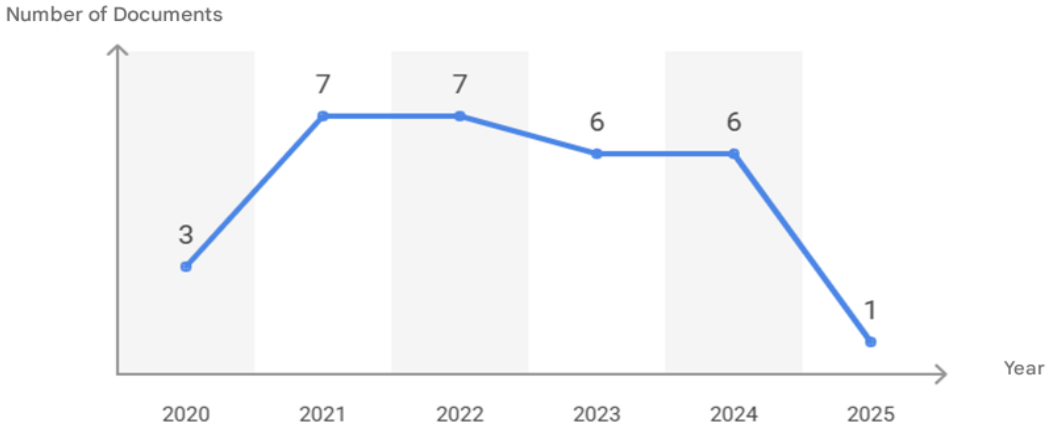


Figure 2 shows the number of article publications (2020-2025) that met the inclusion criteria, for a total of 30 articles. In 2020 there were 3 articles, in 2021 7 articles, in 2022 7 articles, in 2023 6 articles, in 2024 6 articles, in 2025 1 article. Meanwhile, the ranking of articles is detailed in the following table.

Table 2. Article ranking mapping

Number	Journal Ranking	Total
1	Q1	19
2	Q2	5
3	Q3	3
4	Q4	1
5	*Non quartile/Not yet assigned quartile*	2

Table 2 describes the distribution of articles on *Exploratory Factor Analysis* (EFA) based on the Quartile rank in the Journal Rank (*ScimagoJR*), a total of 19 articles in the Q1 Ranking, and in the Q2 ranking there are 5 articles, while in the Q3 ranking there are 3 articles, and 1 article is in the Q4 ranking, and finally as many as 2 articles that have been indexed by *Scopus* but have not yet published the Quartile ranking.

The Use of Exploratory Factor Analysis (EFA) in Validation of Assessment Instruments

Exploratory Factor Analysis (EFA) is a statistical technique used to identify the latent structure of observed variables (W. H. Finch & Finch, 2021). In the validation of assessment instruments, the EFA plays an important role in exploring the dimensions or constructs of the item before it is confirmed through *Confirmatory Factor Analysis* (CFA) (Arifani et al., 2023). EFAs are widely used in various fields due to their ability to reduce complex data into simpler, easy-to-understand structures.

In psychology, the EFA is widely used to develop a measuring tool related to students' psychological conditions that affect learning processes and outcomes, such as academic stress (Zurlo et al., 2020), *self-efficacy* (Peterson et al., 2022), Resilience (Hsing et al., 2022), and *Problem-solving* (Do et al., 2022). For example, instruments to measure exam anxiety or emotion regulation can be structured with the EFA to identify key factors that affect students' responses to learning. The results can be used by teachers, counselors, and researchers to design more appropriate interventions.

In the social field, EFA is used to understand students' or teachers' perceptions of social values (Narmaditya et al., 2024; Yıldırım et al., 2023), School Culture (Erdağ, 2021), or inclusive learning practices (Vantieghem et al., 2020). For example, the development of a scale of students' perception of the fairness of learning evaluation with EFA can reveal dimensions such as clarity of criteria, teacher consistency, and student participation. These findings are useful for policymakers to design more equitable grading systems and encourage student engagement in learning.

In Islamic Religious Education, EFA is used to ensure the validity of the construct, that is, that the item actually measures the aspect in question. For example, the EFA verifies self-assessment items in the Aqidah Akhlak subject to reflect spiritual and social attitudes (Rohmad et al., 2023), and validating the *Technological, Pedagogical, and Content Knowledge* (TPACK) framework in the teaching of religious moderation with four main factors (Hanafi et al., 2024). On the Daily Muslim Religiosity Assessment Scale, the EFA identifies three main dimensions: sinful acts, recommended actions, and physical worship (Bhatti et al., 2021; Ertit, 2023). Thus, the EFA plays a role as the first step in ensuring a valid and reliable instrument.

In the field of education in general, the EFA is important to ensure the validity of the construct of cognitive assessment instruments (Cano et al., 2021), Affective (Silverman et al., 2022), and psychomotor (Amorim et al., 2022). When developing a measurement tool to assess critical thinking, collaboration, or creativity, the EFA helps identify the underlying dimensional structure. This supports the preparation of instruments that are reliable and valid both theoretically and empirically, so that the results can be used accurately in learning decision-making.

The research mapping of *Exploratory Factor Analysis* (EFA) can be seen in the following table:

Table 3. *Exploratory Factor Analysis* (EFA) research mapping

Year	Psychology	Social	Education/PAI
2020	✓	✓	
2021		✓	✓
2022	✓		✓
2023		✓	✓
2024-2025			✓

Weaknesses and General Limitations of Exploratory Factor Analysis (EFA) in Validation of Assessment Instruments

Exploratory Factor Analysis (EFA) is a statistical technique commonly used in the development and validation of assessment instruments to identify the latent structure of a number of indicators (W. H. Finch & Finch, 2021). Although the EFA excels at exploring the relationships between variables without the initial assumption of a number of factors, its application faces a variety of methodological challenges (Howard, 2023). One of the main challenges is determining the right number of factors (H. Finch, 2025). Because errors in this determination can result in structures that do not correspond to the reality of the data (W. H. Finch, 2020). Too few factors can overlook important information, while too many factors lead to complex and difficult to interpret results, which ultimately degrades the validity of the construct (Haslbeck & van Bork, 2024).

One of the weaknesses in the implementation of the EFA is the misunderstanding between the EFA and the *Main Component Analysis* (PCA), which although often used interchangeably, have different purposes and assumptions. EFA aims to identify latent structures between items, whereas PCA simply reduces data to key components without considering latent constructs (Avşar, 2022). Errors in choosing or interpreting this method can result in erroneous conclusions regarding the validity of the construct. In addition, the presence of outliers can also affect the accuracy of estimating the number of factors, as deviant values can disrupt the data structure and lead to incorrect interpretation of the latent structure of the instrument (W. H. Finch, 2024; Y. Xia, 2021)

Another challenge in the implementation of the EFA is weak methodology selection and inadequate reporting, where many studies ignore evidence-based guidelines, making the results less reliable and difficult to replicate (Manapat et al., 2023). The lack of transparent documentation regarding extraction methods, rotations, and factor retention criteria exacerbates this problem (Cosemans et al., 2022; W. H. Finch, 2020). The lack of applicative examples of the implementation of recommended EFA practices is also an obstacle in improving the quality of analysis in the field.

One of the technical limitations of the EFA is its inability to model the correlated residues between indicators (Van Kesteren & Kievit, 2021). Correlations between measurement errors due to similarities in content, language style, or presentation context cannot be accommodated because the EFA assumes all independent residues. As a result, the resulting factor structure can be less accurate and do not reflect the real relationship between the indicators (Ferrando et al., 2024; Montoya & Edwards, 2021).

Exploratory Factor Analysis (EFA) in the Development of Assessment Instruments

a. Validity of Assessment Instruments in the Psychology, Social and Education in General Based on Exploratory Factor Analysis (EFA)

Exploratory Factor Analysis (EFA) has been used extensively since the 1960s to identify the factor structure of various variables (Lloret-Segura et al., 2014). This method is effective in developing psychological instruments, such as *Adolescent Mental Problem Questionnaire* (AMPQ) in uncovering adolescent mental health factors (Hariharan et al., 2023). as well as a tool for measuring resilience and problem-solving related to academic stress and student well-being (Adawiyah & Pramuka, 2017).

In the social field, *Exploratory Factor Analysis* (EFA) is used to evaluate social values in schools through the analysis of students' perceptions of social justice, with dimensions such as the suitability of norms and behaviors, dominance of school values, preferential discrimination, and forms of reinforcement (Llorens et al., 2024). The EFA is also used in the testing of the inclusive practice index to assess the extent to which inclusive practices are implemented in schools and identify elements that need to be strengthened (Chansa-Kabali & Nyoni, 2024).

Exploratory Factor Analysis (EFA) is also used to develop and validate cognitive, affective, and psychomotor assessment instruments. On the cognitive aspect, the EFA ensures that the item measures dimensions such as algorithmic and critical thinking (Sawji et al., 2024); on the affective aspect, separating factors such as open-mindedness and the search for truth (X. Wang et al., 2019); and in psychomotor, identifying physical skill factors so that items reflect abilities consistently (Putro et al., 2024).

b. Validity of Islamic Religious Education Assessment Instrument (PAI) Based on Exploratory Factor Analysis (EFA)

In PAI *Exploratory Factor Analysis* (EFA) is used to ensure the suitability of the item with the dimensions being measured, such as in the self-assessment instrument of Aqidah Akhlak (Husain et al., 2024). The study of Islamic piety reveals five factors: ritual, faith, integrity, family love, and justice. The EFA is also used to validate the TPACK framework in the teaching of religious moderation with four main factors (Inayati et al., 2023), as well as in the development of a scale of daily Muslim religiosity assessment by identifying various dimensions of religiosity (Amalia et al., 2023).

The theoretical foundation of EFA in PAI is based on its ability to reduce data complexity and identify latent variables (Sabilan et al., 2020). Its application to the instruments of Aqidah Akhlak and religious moderation provides important insights into the relevant dimensions of Islamic piety and educational practices (Husain et al., 2024). However, there are still methodological and reporting challenges, so better criteria and guidelines are needed for the implementation of EFA in the context of PAI (Alotaibi, 2024).

Overcoming Common Weaknesses and Limitations of Exploratory Factor Analysis (EFA)

Determining the number of factors in an *Exploratory Factor Analysis* (EFA) is challenging because no single method is always optimal, especially when the data is incomplete. Common techniques used include *Parallel Analysis*, *fit indices*and *Forest Factor* (Lee & Cham, 2024). Recent research proposes new approaches such as minimizing prediction errors in test data and the use of machine learning algorithms. Various software now supports these methods more flexibly and efficiently (Goretzko & Bühner, 2020).

Misunderstanding between EFA and *Main Component Analysis* (PCA) can be minimized through training and workshops that clearly explain the differences in theory and its application (Phakiti, 2018). This material also needs to be included in the statistics curriculum and research methodology. Written guidance, best practices, and flowcharts or decision trees can help researchers choose appropriate methods based on their goals and data types (Norris & Lecavalier, 2010).

The residual correlation between indicators is a limitation in EFA. To overcome this, innovative approaches such as more sensitive detection procedures, the use of *Exploratory Structural Equation Modeling* (ESEM), and alternative rotation methods capable of capturing complex data structures (Scharf & Nestler, 2019). The effectiveness of each method depends on the characteristics of the data and the objectives of the study, so the selection of an approach still requires careful methodological considerations (Ferrando et al., 2022).

The determination of the number of factors, misunderstandings between the EFA and PCA, and the residual correlation between the indicators are the main challenges in the implementation of EFA. The solutions include modern statistical methods such as parallel analysis, fit indices, machine learning algorithms, as well as educational approaches through training, curriculum, and practical guidance. Innovations such as ESEM and alternative rotation methods also expanded the analysis strategy. The selection of the right method still requires careful consideration according to the characteristics of the data and the purpose of the research. Solutions to address common weaknesses or challenges in the EFA technique can be seen in the following table:

Table 4. Solutions in overcoming EFA's challenges/weaknesses

Challenges/Weaknesses of EFA	Proposed Solutions
Difficulty in determining the right number of factors	*Parallel analysis, fit indices, Factor Forest*, predictive methods based on test data errors, machine learning algorithms
Misunderstandings between EFA and PCA	Training and workshops, integration of material into the curriculum, written guidance, use of flowcharts
Correlated residual between indicators	New detection procedures, use of ESEM, alternative rotation methods for complex data structures

Implications for Practice, Policy, and Instrument Development

The results of this study provide a number of important implications that can be utilized by various stakeholders in the field of education. For education practitioners, especially teachers and school counselors, these results show the need for a basic understanding of the validity of constructs and the application of *Exploratory Factor Analysis* (EFA) in assessing the reliability of measuring instruments used in the classroom. Brief case-study-based training on how the EFA works in filtering out weak items can help improve the accuracy of daily assessments.

For instrument developers, both in academia and assessment institutions, this study emphasizes the importance of implementing EFA procedures in accordance with best practice guidelines, including the use of parallel analysis, reporting of fit indices, and selection of appropriate rotation methods. The use of modern techniques such as ESEM can also be considered to overcome the limitations of conventional EFA, especially on complex data.

For education policymakers, these findings show the need to design policies that encourage the use of evidence-based assessment instruments, as well as provide technical training for teachers and education staff related to instrument validation. The integration of factor analysis topics in pre-service teacher education programs and in continuous professional development will strengthen assessment competencies at the school and regional levels.

4. CONCLUSION

The use of *Exploratory Factor Analysis* (EFA) has proven to be widespread in the validation of assessment instruments to explore the latent structure of various constructs, both in general, social, and Islamic religious education. EFAs make a meaningful initial contribution to the validity of cognitive, affective, and psychomotor instruments. Studies show that EFA is effective in identifying hidden dimensions in the measurement tools such as evaluation fairness, religiosity, and TPACK competence. The practice still faces challenges such as misestimating the number of factors, misunderstandings between EFA and PCA, and limitations in dealing with residual correlations. The next step requires the use of new methods such as *parallel analysis* and ESEM, as well as the integration of EFA materials into training and research curriculum. Further research needs to be directed towards the development of applicable guidelines for EFA in various educational contexts as well as the exploration of the combination of EFA and modern statistical methods to produce instruments that are increasingly powerful in terms of validity and practicality.

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