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Innovation Capacity in the Management System of Islamic Boarding School Education Institutions : Quality Test of Instruments through Exploratory and Confirmatory Factor Analysis

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Abstract: This study aims to test the validity and reliability of instruments measuring the variable of innovation capacity in the management system of Islamic boarding school education institutions in Jambi City. This research method employed a cross-sectional survey design with a quantitative approach. The sample size for this study consisted of 162 teachers (Ustad/Ustadzah) in Islamic boarding school education institutions. Quantitative data were analyzed using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) using SPSS 23 and AMOS 18. The results of this study indicated that EFA identified five factor structures to construct the dimensions of Innovation Capacity (IC), namely Opportunity Exploration (OE), Idea Sustainability (IS), Idea Introduction (II), Idea Emergence (IE), and Idea Realization (IR). Meanwhile, these findings were verified and confirmed by CFA regarding the factorial validity analysis of the Innovation Capacity dimension from the EFA testing results. This study suggests that future innovation capacity instruments require further adjustment to enhance the level of reliability and the ability to explain differences related to the measured constructs within different contexts, cultures, and conditions.

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Introduction

The reality in the world of education is experiencing a constant need for innovation. The rapidly changing demands of the labor market require the acquisition of skills and knowledge that are often not available in educational programs (World Economic Forum, 2020). Additionally, there is an ongoing debate about maintaining the quality of education related to the improvement of teaching methods, assessment, and their impact on teacher competence. Current innovations in education, for instance, involve integrating twenty-first-century skills or soft skills such as communication, collaboration, and flexibility into the curriculum to support students' entrepreneurial abilities (Theoharis & Scanlan, 2020). Furthermore, there is discussion about the implementation of new innovations and technologies in the classroom that promote new approaches to the teaching and learning process (Muhaimin et al., 2019).

In this context of global economic instability, creating organizational conditions to enhance the learning process and facilitate the creation of organizational knowledge is the most urgent and necessary element. Through this facilitative environment, creative knowledge can be generated; and it is the most common factor for organizations to sustain (Hsu & Lamb, 2020). Some debates regarding the challenges of Islamic Boarding School

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Institutions (Pesantren) today revolve around three specific issues, namely: (1) The need for studies on innovation and modernization in Pesantren institutions, which are related to the context of Indonesian society currently undergoing a process of development and modernization. In education, aspects closely related to innovation and modernization are very clear. Islamic education, especially Pesantren, in the history of the Indonesian nation with its institutional background, has changed in terms of curriculum, learning, leadership, management, and media. (2) With the enactment of Law Number 18 of 2019 concerning Islamic Boarding Schools, which regulates the implementation of educational functions, da'wah functions, and community empowerment functions. According to this law, the implementation of Pesantren education is considered part of the national education system. Law Number 18 concerning Islamic Boarding Schools in 2019 provides a legal basis for recognizing the role of Pesantren in shaping, upholding, and preserving national unity, traditions, values, and norms, as well as the types and activities of the Unitary State of the Republic of Indonesia educators and educational personnel professionalism, as well as quality assurance processes and methodologies. (3) The issue currently challenging Pesantren is the emergence of a digital information-based economy and a society that has changed the way wealth is created by people working online or remotely (Panut et al., 2021). Working with technology and information requires people to have different skills; for long-term work life, skills based on the use of brain skills rather than manual skills are necessary (Senge et al., 2001).

As part of the main research instrument process, EFA helps identify the initial factorial structure. At the same time, CFA validates and tests the fit of the hypothesized model with observed data, making both crucial in the data analysis steps of the research. In this regard, the Innovation Capacity variable was developed and validated in Europe; hence, this research aims to assess the cross-cultural validity of the Innovation Capacity variable in a sample of Pesantren educators in Indonesia. Existing literature indicates that comparative research is important to test whether the Innovation Capacity instrument is accepted universally. Empirical research also reveals that the reliability of the Innovation Capacity instrument varies between countries. EFA testing provides initial insights into how variables can be classified and organized into interrelated dimensions or factors, while CFA validates the factorial structure identified through EFA.

Operationally, innovation capacity is defined as the creation of ideas, products, or service processes with novelty and/or improvement in Pesantren institutions, consisting of dimensions such as Opportunity Exploration, Idea Emergence, Idea Introduction, Idea Realization, and Idea Sustainability. These dimensions were developed into research instrument grids. To measure the construct of the Innovation Capacity variable, this research adapts the instrument developed by (Messmann & Mulder, 2014), namely Opportunity Exploration (EP), Idea Emergence (PG), Idea Introduction (MG), Idea Realization (RG), and Idea Sustainability (KG). The purpose of this research is to test the validity and reliability of the Innovation Capacity variable instrument in the management system of Pesantren educational institutions in Jambi City. Specifically, this research will ascertain to what extent the Innovation Capacity variable is a reliable instrument for measuring the attitudes of Pesantren educators in terms of factorial validity and construct.

Research Method

This research method employed a cross-sectional survey design with a quantitative approach. The cross-sectional survey in this study was a procedure in quantitative research

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that provided an opportunity to investigate a sample or the entire population at one time to describe the attitudes, opinions, behaviors, or characteristics of the population (Creswell, 2012). The research stages (EFA & CFA) were part of the main research stages that tested a complex and unique model using SEM analysis. Using random sampling technique, this research is conducted by selecting individuals randomly (Piccioli, 2019). Subsequently, after the data screening process for all respondents who returned the questionnaire, data screening became an essential part of the data preparation method to provide maximum information. Especially when analyzing data quantitatively, it is recommended to conduct data screening first. Data screening aims to predict unavailable or missing data. Out of the total sample that returned the questionnaire after undergoing the screening process, only 587 main data were accepted for analysis as the main research sample. Then, testing was carried out to meet SEM assumptions, and 162 samples were taken as a pilot study in EFA and CFA testing.

The research starts by translating the original questionnaire into Indonesian before the question items are used to test validity and reliability. The translated questionnaire into Indonesian was consulted with four bilingual language experts. To measure the construct of the Innovation Capacity variable, this research adapts the instrument developed by (Messmann & Mulder, 2014), namely Opportunity Exploration (EP), Idea Emergence (PG), Idea Introduction (MG), Idea Realization (RG), and Idea Sustainability (KG). Each sub-construct has two to four item statements, and the questionnaire consists of 16 questions measured on a Likert scale with a seven-point scale ranging from 1 (strongly disagree) to 7 (strongly agree).

The data analysis of this research employs exploratory factor analysis (EFA) using SPSS 23.0 software. EFA is conducted to determine the structure and explore factors in the indicator questions of the Innovation Capacity variable. As this research uses an existing scale originally developed in Europe (Germany), it is crucial to validate the scale. EFA, as an analysis, is used to explore how any factors can be used, whether these factors correlate, and which observed variables appear to best measure each single factor (Reynolds, 2020). This research identified the Kaiser Meyer Olkin (KMO) value, Bartlett's value, loading factor, eigenvalue, scree plot, and rotation of Oblimin with Kaiser Normalization. The KMO index ranged from 0 to 1, with values above 0.50 suitable for factor analysis (Jung & Lee, 2011), while scores above 0.80 were considered highly satisfactory (Williams et al., 2010). Bartlett's Test of Sphericity was significant ($p < 0.05$). For (Reynolds, 2020), the overall loading factor value for each item above 0.50 was significant to confirm the questionnaire's meaningfulness. Eigenvalue and scree plot values also indicated the proportion of variance extracted by each factor through factor analysis (Schreiber et al., 2006), where factors with eigenvalue values less than 1.0 were removed from the factor list. Furthermore, the data in this study were also analyzed with Confirmatory Factor Analysis (CFA) using AMOS 23.0 applied to the first order. Reynolds (2020) explained that the goodness of fit indication was evaluated using chi-square ($\chi 2$) ($P > 0.05$), Comparative Fit Index (CFI> 0.90), Tucker Lewis Index (TLI> 0.90), and Root Mean-Square Error of Approximation (RMSEA <0.08).

Results and Discussion

Exploratory Factor Analysis (EFA) Innovation Capacity Variable

Testing EFA (Exploratory Factor Analysis) and CFA (Confirmatory Factor Analysis) are two crucial steps in data analysis within research (Watkins, 2018). EFA is used to explore the data structure without having clear hypotheses about the factorial structure beforehand. Through EFA, researchers can identify the underlying dimensions of measured constructs and

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group interrelated variables. It provides initial insights into how variables can be classified and organized into interrelated factors. On the other hand, CFA is used to validate and test how well the identified factorial structure fits the existing data. With CFA, researchers can examine if the theoretically proposed model aligns with the observed data. It aids in measuring the reliability and validity of measurement instruments and ensuring that the proposed model fits the observed data. Overall, EFA and CFA complement each other in the data analysis process, with EFA assisting in the initial identification of factorial structure and CFA in validating and testing the fit of hypothesized models with existing empirical data.

The research instrument employed a scale previously developed in Western countries, hence it is important to scrutinize and revalidate its appropriateness before adoption. EFA was employed to explore the relevant number of factors, inter-factor relationships, and variables best measuring each single factor. This study pays attention to the values of Kaiser Meyer Olkin (KMO) Index, Bartlett's value, factor loading, eigenvalue, scree plot, and varimax rotation with Kaiser Normalization. Standard criteria indicate that KMO values should fall within the range of 0 to 1, with values above 0.50 considered adequate for factor analysis, while values above 0.80 are deemed highly satisfactory. The results of Bartlett's Test of Sphericity indicate significance ($p < 0.05$). Furthermore, factor loading values for each item should exceed 0.50 to ensure questionnaire significance and validity. Eigenvalues and scree plots are also utilized to evaluate the proportion of variance contribution explained by each factor. Factors with eigenvalues less than 1.0 are eliminated from the analysis. Thus, the results of the factor analysis (EFA) for the Innovation Capacity variable have been delineated using an approach that encompasses the aforementioned crucial parameters. The statistical processing results for the factor analysis (EFA) of the Innovation Capacity variable are as follows:

Table 1. KMO and Bartlett's Test (Innovation capacity)

Assumption of Eligibility		Value
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy.		.737
Bartlett's Test of Sphericity	Approx. Chi-Square	2248.303
	df	136
	Sig.	.000

Exploratory Factor Analysis (EFA) is also utilized to establish constructs and convergent validity using the principal component analysis technique with the Varimax rotation method, as shown in the table above. The statistical criteria in this study meet satisfactory standards. The KMO value is 0.737 > 0.60, providing information on the adequacy of the number of items available for each analyzed factor (n=162). Additionally, Bartlett's Test of Sphericity indicates that the scores appear statistically significant [$\chi 2 = 2248.303$; Sig. <0.000]. Therefore, it can be concluded that the use of factor analysis (EFA) is acceptable for the data collected in this study.

EFA begins by considering all 22 items measuring four aspects of Exploration Opportunities (EP), Idea Sustainability (KG), Introducing Ideas (MG), Emergence of Ideas (PG), and Realization of Ideas (RG). Several items measure each aspect dimension. The results of EFA processing are as follows:

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Table 2. Exploratory Factor Analysis (EFA) Result

Factor	Dimensions	Items	Communalities	Eigen value	% of Variance	Component Matrix				
						1	2	3	4	5
Innovation Capacity (KI)	Idea Realization (RG)	RG45	.921	3.653	21.489	.957				
		RG46	.886			.933				
		RG47	.837			.909				
		RG44	.745			.859				
	Sustainability of Ideas (KG)	KG55	.759	3.107	18.276		.865			
		KG54	.707				.836			
		KG56	.695				.819			
		KG53	.669				.805			
		KG50	.500				.680			
	Idea Generation (PG)	PG40	.944	2.564	15.081			.965		
		PG38	.941					.964		
		PG39	.700					.827		
	Opportunity Exploration (EP)	EP36	.815	2.290	13.473				.901	
		EP35	.794						.882	
		EP37	.710						.828	
	Introducing Ideas (MG)	MG41	.806	1.597	9.394					.895
		MG42	.783							.880

The table above provides information on the values of extraction communalities, eigenvalues, percentage of variances, and component matrix factor loadings explained by the four sub-constructs of the Innovation Capacity (KI) variable. Firstly, the extraction communalities values represent the variance in each item calculated before and after factor analysis. Communalities values below 0.50 for each item are dropped from further analysis (Hair et al., 2010). From the analysis, the dropped items due to values (<0.50) are MG43, KG48, KG49, KG51, KG52, leaving only 17 questionnaire items. Subsequently, the values of extraction communalities indicate that all extraction communalities values of the items range from 0.669 to 0.944, exceeding the 0.50 threshold, indicating satisfactory values of extraction communalities.

Moreover, from the table above, five factors with eigenvalues >1 emerge from the EFA. The factors of the Innovation Capacity (KI) variable and their contributions are as follows: Exploration Opportunities (EP) 13.473%, Idea Sustainability (KG) 18.276%, Introducing Ideas (MG) 9.394%, Emergence of Ideas (PG) 15.081%, and Realization of Ideas (RG) 21.489%. The component matrix after Varimax rotation is used to identify items more associated with each factor. In this study (17 items), the component matrix suggested for measuring the Innovation Capacity (KI) variable meets the criteria by having sufficiently high factor loadings ranging from 0.680 to 0.957 (> 0.50). Another method to determine the correct number of factors to be extracted is to investigate the scree plot graph below. As shown in the graph, the scree plot indicates four factors that eigenvalues can determine (>1)).

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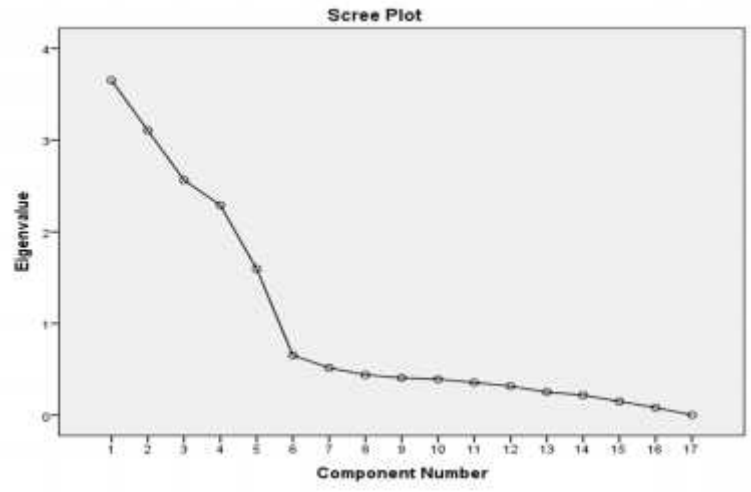

Picture 1. Scree Plot

Next, to assess the construct validity and reliability of the Innovation Capability (KI) variable, the construct validity assessment method by (Hair Jr et al., 2020), Cronbach's alpha (CA) and Composite Reliability (CR) were used to check and test the reliability (reliability of the instrument). Construct reliability is calculated using CA (Cronbach, 2016) and Composite reliability (CR) (Brown, 2002), whose value is accepted if it is above 0.7 (Hair Jr et al., 2020), and the AVE value must be equal to or more than 0.500 (Cohen et al., 2007). The results of testing the KI variable instrument produce validity and reliability as follows.

Table 3. Validity and Reliability of the Innovation Capacity (KI) Variable Construct

Dimensions	Cronbach's Alpha >0,7	Composite Reliability (CR) >0,7	AVE >0,5
Opportunity Exploration	0.843	0.899	0.750
Sustainability of Ideas	0.891	0.912	0.536
Introducing Ideas	0.704	0.83	0.620
Idea Generation	0.910	0.945	0.851
Realization of Ideas	0.937	0.954	0.839

As shown in the table above, all Cronbach Apha and Composite Reliability (CR) are greater than (>0.7). AVE exceeds the acceptable value of (>0.5), and thus, the KI questionnaire items fulfill and ensure instrument reliability (Indicators are consistent in measuring the construct). The table above proves that the Cronbach Alpha value, namely the reliability value of the question items (reliability), which ranges from 0.836 to 0.937, is considered by respondents to have assessed the question items in the "good" category, and respondents are consistently in providing their attitude assessments.

Confirmatory Factor Analysis (CFA) the Innovation Capacity (KI) Variable Construct

In testing the quality of this instrument, EFA suggests a five-factor structure to build the Innovation Capacity (KI) dimension, namely Opportunity Exploration (EP), Idea Sustainability (KG), Introducing Ideas (MG), Idea Generation (PG), Idea Realization (RG). Confirmatory Factor Analysis (CFA) was carried out to verify or confirm the validity of the factorial analysis of the Innovation Capacity dimension from the EFA test results. CFA can provide further evidence of the suitability of the suggested model by considering the structure of factors identified through EFA. The results of the analyzed models will be compared using chi-square ($\chi 2$), CFI, TLI and RMSEA.

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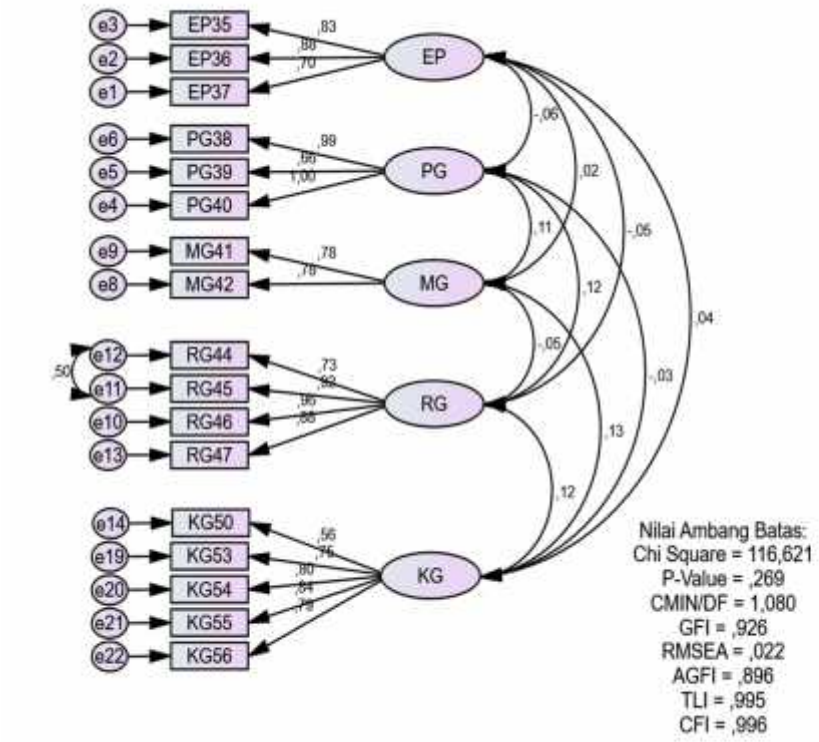
The table below presents the model specifications for post hoc CFA. The CFA results for the three-factor model were well hypothesized. The factor structure achieves an acceptable model that is suitable for the research context (Islamic boarding school in Jambi City). The LK variable measurement model in this test shows the acceptable model fit, χ2 = 21.304, χ2 / df = 0.926, RMSEA = 0.000, TLI = 1.002 and CFI = 1.000. Therefore, the CFA model presented in Figure 16 is the final measurement model that shows the structure of OK in the context of the research location. The CFA first-order results found the following results:

Table 4. Model specification for post hoc (CFA-first order)

Goodness-of-fit index	*Cut of-value*	*Result*	*Judgment*
χ2		116,621	
p-value	*>0,05*	0,269	*Fit*
χ2 / df		1,080	
TLI	≥ 0,90	0,995	*Fit*
CFI	≥ 0,90	0,996	*Fit*
RMSEA	≤ 0,08	0,022	*Fit*

Catatan. χ2: Chi -square goodness of fit; df: Degrees of Freedom; CFI: Comparative Fit Index; TLI: Tucker-Lewis fit index; RMSEA: Root Mean Square Error



Picture 2. CFA First Order Innovation Capacity

The image above informs that the variable measurement model for the Innovation Capacity Variable (KI) between observed variables and latent variables uses the AMOS 23.0 program. Results All factors contain four sub-constructs: Innovation Capacity Variables ranging from 0.56 to 1.00. The research results show that the Factor Loadings exceed the

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established standard, namely >0.50 (Hair et al., 2010), which shows the strength of the convergent validity test. Additionally, the correlations between the five sub-constructs of the Innovation capacity variable ranged from 0.05 to 0.13, indicating acceptable discriminant validity.

Discussion

Based on the results of Validity and Reliability Testing using Factor Analysis (EFA & CFA) and statistical analysis, the questionnaire originating from the Five Dimensions of the Innovation Capacity variable adapted into the Indonesian version, integrated with the English instrument, is deemed acceptable overall. Following the Calibration of the Innovation Capacity Instrument from 23 questionnaire items, 5 items are dropped during the instrument quality testing through EFA and CFA, namely item numbers (MG43, KG48, KG49, KG51, KG52). Therefore, the remaining questionnaire items for further analysis in testing hypotheses on the Innovation Capacity variable are 17 items. The conclusion from the deletion of items from all variables tested is presented. Overall, the data collected from 162 samples (excluding main data samples) through questionnaires are considered sufficiently reliable and valid for conducting large-scale survey research.

To measure the constructs of the Innovation Capacity variable, this study utilizes an instrument developed by (Messmann & Mulder, 2014), which includes Exploration Opportunities (EP), Emergence of Ideas (PG), Introducing Ideas (MG), Realization of Ideas (RG), and Idea Sustainability (KG). The findings of this research are consistent with previous studies by (Goretzko et al. 2021; Kahn, 2006; Messmann and Mulder 2014; Reynolds, 2020; and Schreiber et al., 2006). The pilot study results on the Innovation Capacity variable show that four questionnaire items are eliminated or dropped from further analysis because the communalities values of the items are less than 0.50 (EFA).

Regarding why there are issues with several instrument items from the variable constructs that need to be dropped from further analysis based on validity and reliability in the context of Islamic boarding schools in the city of Jambi, there are two possible explanations that need to be explored. Firstly, some items appear confusing due to language and cultural context differences, thereby resulting in low internal scale consistency in the context of Islamic boarding schools in the city of Jambi. Secondly, some items need to be revised or replaced because they fail to adapt to the educational context, such as in Islamic boarding schools, which are non-profit institutions. For example, according to (Rofiaty, 2019), the Innovation Capacity Variable Questionnaire was initially designed for samples in large organizations. Thus, some items are questioned to be proposed as an attitude and response assessment in the context of Islamic boarding schools in the city of Jambi. Therefore, the researcher decides to remove items that are not suitable for the social, cultural, and respondent understanding contexts and use other more relevant items to meet the needs of educational organizations, especially in Islamic boarding schools.

From a theoretical perspective, the findings of this research contribute to understanding the dimensions of innovation capacity in the context of Islamic boarding schools. The factor analysis results provide in-depth insights into the conceptual structure of innovation capacity, which can serve as a basis for further theory development in this field. Additionally, the implications of this research can assist in formulating a more detailed conceptual framework on the factors influencing innovation in Islamic boarding school institutions. Thus, the findings of this research not only have practical relevance in the context of developing innovation capacity in boarding schools but also make a significant contribution to theory development on innovation in Islamic educational institutions.

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The practical implications of this research are that the use of instruments or scales initially developed in Western countries in the context of Islamic boarding schools in the city of Jambi requires special attention to their validity. Rechecking and revalidating these instruments before their use are crucial steps to ensure relevance and accuracy in measuring innovation capacity. Furthermore, the results of the factor analysis (EFA) provide clear guidance on the underlying factors of innovation capacity in the context of boarding schools, such as exploration opportunities, idea sustainability, introducing ideas, emergence of ideas, and realization of ideas. This provides a strong foundation for boarding schools to identify areas that need to be improved in developing their innovation capacity.

Conclusion

The conclusion from the results of this research is that EFA found five-factor structures to build the Innovation Capacity (KI) dimension, namely Opportunity Exploration (EP), Idea Sustainability (KG), Introducing Ideas (MG), Idea Generation (PG), Idea Realization (RG). Meanwhile, these findings were verified and confirmed by CFA regarding the validity of the factorial analysis of the Innovation Capacity dimension from the EFA test results. This research suggests that future Innovation capacity instruments require further adjustments to increase the level of reliability and ability to explain differences associated with the construct measured in different contexts, cultures and conditions.

Recommendation

The recommendations from this research offer guidance for future researchers, policy makers, and Islamic boarding school managers in efforts to increase the innovation capacity of Islamic boarding school educational institutions. Future researchers are advised to expand the scope of research by involving a wider sample, developing more specific measurement instruments, and combining qualitative analysis methods for a deeper understanding. For policy makers, recommendations include financial support, education and training programs, as well as inter-institutional collaboration to improve Islamic boarding school innovation capabilities. Meanwhile, administrators of Islamic boarding school educational institutions are advised to build a culture of innovation, improve human resources, and build collaboration with other institutions. Through the implementation of these recommendations, Islamic boarding school educational institutions can become more innovative and adaptive educational centers in meeting the demands of the times.

Ensuring the validity of measurement scales is a crucial endeavor in scientific questionnaire development. Construct validity has progressively advanced through extensive prior research. However, further refinements are needed in this scale to enhance reliability and its capacity to elucidate variations across different contexts, cultures, and conditions. Future studies are advised to reassess the model's generalizability and validity through random sample testing. Additionally, validating the instrument across diverse cultures using various methodologies such as habits, Focus Group Discussions, peer interviews, and face-to-face interactions is proposed.

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