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Three key indicator of elementary school teachers' readiness in differentiated instruction: An exploratory factor analysis

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Abstract The main purpose of this research is to develop a measure to determine the readiness perceptions of elementary school teachers toward differentiated mathematics learning. Exploratory factor analysis was conducted within the scope of scale validity, and its internal consistency was analyzed for reliability. Data for the exploratory factor analysis were collected from 112 elementary school teachers in various regions of Indonesia who had implemented differentiated mathematics learning during the academic year 2022--2023. Aiken's analysis was used to measure the content validity from expert judgment. As a result of the exploratory factor analysis, three underlying factors were formed in the construction of the construct validity of the instrument: MR1 (learning management), MR2 (coaching and continuous learning), and MR3 (teaching strategies). The questionnaire instrument, consisting of 27 items, had factor loadings between 0.385 and 0.851. The significant values for EFA were overall MSA = 0.89, χ^2 = 1944.1; df = 351; SRMR = 0.057; and CFI = 0.97, indicating an acceptable level of fit that confirms the three-factor structure. The findings suggest that the developed scale is a valid and reliable measure for determining the readiness perceptions of elementary school teachers toward differentiated mathematics learning. These insights provide practical implications for educational policymakers and teacher training institutions, enabling them to design more effective professional development programs. Such programs can focus on equipping teachers with the skills and strategies necessary to implement differentiated instruction, ultimately enhancing educational outcomes and addressing diverse student needs under the Merdeka Curriculum.

Keywords: differentiated mathematics learning, perception scale, elementary school teachers, exploratory factor analysis

1. Introduction

The development of the Merdeka Curriculum in Indonesia, first introduced by the Minister of Education, Culture, Research, and Technology (Mendikbud) Nadiem Makarim in 2019, continues to progress. This curriculum is designed to provide students and teachers with the freedom to learn or think independently and to prepare a resilient, intelligent, creative generation with character in line with the values of the Indonesian nation. One of the main focuses of the Merdeka curriculum is on essential material, especially literacy and numeracy, so that students can have better abilities in these aspects.

By the end of 2022, more than 151 thousand educational units had implemented the Merdeka curriculum, with Kemendikbudristek continuously making breakthroughs to optimize the implementation of this curriculum. The implementation of the Merdeka curriculum in 2023 is still voluntary, giving educational units the opportunity to reflect and provide feedback on their implementation in 2022. The Merdeka curriculum, with its focus on a more flexible and student-centered approach, is closely related to the concept of differentiated learning. Differentiated learning is a teaching method designed to meet the unique learning needs of each student by adjusting materials, activities, and assessments (Tomlinson et al, 2003; Tomlinson, 2001). Differentiated learning is an approach that adjusts to student needs (Gusteti & Neviyarni, 2022); Deunk et al., 2018), readiness to learn, student interest (Tomlinson et al., 2003; Faiz et al., 2022) modifies learning content (Roy et al., 2012) and adapts instruction for weaker students (Deunk et al., 2018). This differentiated learning is not about discriminating between students (Cindyana et al., 2022).

Although the model of differentiated learning is not a new concept in education, it has significantly developed over the past few decades. The concept of differentiated learning was first developed and popularized by Carol Ann Tomlinson, an American educator and author, in the late 1990s. Her approach focuses on teaching methods that adapt to the individual learning needs of students (Tomlinson, 1999; Tomlinson et al., 2003). Several countries have been successful in implementing differentiated learning. Since the early 2000s, many schools in the USA have adopted this approach in classrooms to address the diverse needs of students (Onyishi & Sefotho, 2020). In Australia, differentiated learning has become a part of the national curriculum framework. This encourages teachers to accommodate differences in student abilities and ensure that all students have access to quality education (Gibbs, 2023). In Canada, several provinces have integrated differentiated learning into their teaching standards, focusing on inclusive approaches and tailoring learning to individual needs (Whitley et al., 2023). In the UK, differentiated learning has also become a common practice in many schools, particularly to support students with special educational needs (SENs) (Avramidis et al., 2010). Singapore, known for its innovative education system, has adopted a differentiated approach in recent years to provide more tailored and inclusive education (Choon & Pang, 2021). Previous research has shown that differentiated learning can create rich experiences and understanding from various learning processes (Hodges & McTigue, 2014).

In Indonesia, differentiated learning is closely related to the educational philosophy of Ki Hajar Dewantara, namely, the "Among" system, where teachers must guide students to develop according to their nature. One important aspect of the educational process is the readiness of teachers to implement effective learning methods (Herwina, 2021; Suprayogi et al., 2017; Hermanto, 2022; Jannah, 2022). Despite its global recognition, the implementation of differentiated instruction in Indonesia faces unique challenges under the Merdeka Curriculum. These include limited teacher training, lack of resources to support individualized learning, and the traditional focus on uniform teaching methods. This study addresses these gaps by exploring the readiness of elementary school teachers to adopt differentiated mathematics instruction.

According to Schöllhorn (2000), differential learning is a motor learning model that emphasizes the importance of movement variability and is rooted in the dynamic systems theory of human movement (Whitley et al., 2023; Unal, 2022; Adams & Pierce, 2006). The urgency of differentiated mathematics learning at the elementary school level is significant, especially considering the importance of mathematics in the basic education curriculum and the diversity of student learning needs (Amin et al., 2023). The suboptimal implementation of differentiated learning in mathematics poses a unique problem in the implementation of the Merdeka curriculum in the learning process. This means that teachers have not yet guided students according to their potential, interests, talents, and abilities to achieve learning objectives (Ellis et al., 2007; Yigletu et al., 2023). In reality, the results of identification show that the implementation of learning activities has not changed much, where the learning system still treats all students the same without considering the diversity of individual abilities (Safarati & Zuhra, 2022; Deunk et al., 2018).

Therefore, teacher readiness is crucial in determining the success of managing learning. The findings indicate that novice teachers are significantly less adept than teachers with more than three years of experience (van Geel et al., 2022). The skills required for teaching vary greatly with experience. Teachers can decide on the different elements of differentiated learning, namely, content, process, product, and learning environment (Wahyuningsari et al., 2022). In this context, teachers must become masters of differentiated instruction to meet student needs, remediate or accelerate instruction, and provide learning and growth opportunities for all students (Susongko et al., 2021; Tomlinson et al., 2015).

Given the importance of the teacher's role in differentiated learning, this study aims to conduct an exploratory factor analysis (EFA) on the readiness of elementary school teachers in implementing differentiated mathematics learning. EFA is a multivariate analysis fundamental in determining the constructs of theory or influencing variables (Watkins, 2018). This factor analysis measures latent variables, where latent constructs cannot be directly measured by a single variable (Santoso & Istiyono, 2022; Tavakol & Wetzel, 2020); for example, in this case, the factors affecting teacher readiness in teaching differentiated mathematics through the relationships between items in the teacher readiness questionnaire. EFA serves as an analysis to build evidence on the basis of internal structure, retaining only the items with high loadings that correspond to the measured factors (Tavakol & Wetzel, 2020). EFA was chosen as the research method for its ability to identify the underlying factor structure of a set of variables, which, in this case, are aspects of teacher readiness. This study aims to uncover the main factors influencing teacher readiness, which will provide insights for education policy makers and teacher training institutions in designing more effective professional development programs.

This study is important considering the ongoing changes in curriculum and teaching methods, as well as the need to improve the quality of mathematics education in Indonesia. This study represents an initial step in preparing teachers to develop differentiated learning models. By understanding the factors influencing teacher readiness in differentiated mathematics learning, it is hoped that this will contribute to efforts to enhance the quality of learning in elementary schools and ultimately improve student mathematical competence.

2. Materials and Methods

2.1. Research Design

This research is a quantitative study aimed at constructing a structural model from a set of variables, specifically teacher readiness in differentiated mathematics learning. The study's respondents include primary schoolteachers who have implemented the Merdeka curriculum and differentiated learning models across five different dimensions. The following processes were used to develop the questionnaire: (a) conducting interviews with experts and face validity; (b) content validation; (c) exploratory factor analysis; and (d) reliability testing. This research aims to develop and validate a questionnaire for primary school teacher readiness in the implementation of differentiated mathematics learning. The study was conducted from June to November 2023.

2.2. Interviews with Experts and Face Validity

At this stage, the researcher interviewed three elementary school mathematics teachers and four instructors from the School Initiator and Teacher Initiator Facilitators of the Merdeka Curriculum Kemdikbudristek about relevant items in various constructs of mathematics satisfaction. The researcher sought the expertise of educators from various education sectors in Central Java to develop a more comprehensive and extensive understanding of mathematics satisfaction. After the interviews were evaluated and analyzed, the researcher produced 27 items via face validation. The researcher's subjective assessment of the presentation and application of the measurement tool, including whether the items appeared relevant, sensible, simple, and clear, is referred to as facial validity (Oluwatayo, 2012). The 27 items were classified into three constructs: sixteen for Learning Management, four for Continuous Learning, and seven for Teaching Strategies.

2.3. Content Validation

The extent to which the elements of an instrument accurately reflect its content domain is known as content validity (Zamanzadeh et al., 2015). The content validity of the questionnaire was determined by the researcher via Aiken's V technique, which was developed by Aiken (1980). Four instructors from the School Initiator and Teacher Initiator Facilitators of the Merdeka Curriculum Kemdikbudristek were asked by the researcher to rate the relevance of items to various constructs of teacher readiness in differentiated mathematics learning. Each item received a score from the raters on how relevant it was to a specific construct. For each item, the lowest possible score and the maximum score were 1 and 5, respectively. The formula for Aiken's V is $V = \sum \{(r - lo)/[n\ (c-1)]\}$, where r is the score that could be given by faculty raters for an item, lo is the lowest possible score given for each item, c is the maximum score that could be given for each item, and n is the number of raters. Interpretation of values ≥ 0.80 (excellent), 0.70–0.79 (good), and 0.60–0.69 (adequate) may require some revisions to enhance its validity; values < 0.60 (low) indicate that the item may not have adequate content validity and may require revision or removal from the instrument (Capinding, 2023).

2.4. Sample

Currently, the implementation of the Merdeka curriculum has not been fully executed; thus, researchers have focused more on teachers in Grades I and IV, who were involved as respondents. The distribution of respondents was limited to the Central Java region, capturing data from 112 respondents. The respondents consisted of 87 women (77.67%) and 25 men (22.32%). The sample size was based on the rule of 300. According to Garson (2008), there should be at least 300 cases in the sample size to conduct factor analysis. Furthermore, Bryant and Yarnold (1995) argued that a person's sample should be at least five times the number of variables. The number of items analyzed in this study is 27; therefore, there should be at least 135 responses. However, the researcher only obtained survey results from 112 samples. To address this limitation, a KMO test was conducted to determine sample adequacy. The KMO value was 0.918, indicating that the sample size was sufficient for factor analysis, despite not meeting the ideal threshold. It is important to note that the regional focus on Central Java and the relatively small sample size may limit the generalizability of the findings to other regions or broader educational contexts in Indonesia. Future research should aim to include a larger and more diverse sample to ensure broader applicability of the results. Google Forms accompanied by a consent letter for respondents, which was signed by the campus director, were used. There was no obligation to answer the Google Form. The researchers also secured the participants' identities, and the data provided were kept confidential to protect and consider the respondents' privacy.

2.5. Data collection

Google Forms were used to collect the data. The form was distributed to 600 elementary school teachers who had implemented differentiated mathematics learning. The researcher sent the Google Form to 20 elementary schools in Central Java. After five months, once all the schools had responded, the Google Form was closed. This survey received 112 responses.

2.6. Data analysis

Exploratory and confirmatory factor analysis techniques were used to generate evidence of the construct validity of the scale. To determine the reliability of the scale in terms of internal consistency, the total item score of each item and the Cronbach's alpha reliability coefficient were calculated to determine which items would remain in the scale. Exploratory factor analysis was conducted via the R studio software package.

Next, we checked whether the data were suitable for factor analysis. The sample size was taken as the first criterion. The researcher used the Kaiser–Meyer–Olkin (KMO) measure to assess the suitability of using factor analysis on the dataset. A

KMO value between 0.8 and 1.0 indicates that the sample is adequately sufficient (Shrestha, 2021). A KMO value higher than 0.50 means that factor analysis can be performed (Zeynivandnezhad & Kanooni, 2019). To test whether the overall intervariable correlations were significant, Bartlett's test of sphericity was conducted. Bartlett's test of sphericity needs to be less than 0.05 for factor analysis to be considered appropriate (Sakti et al., 2023). Additionally, the researcher used the varimax rotation method. At one level of factor analysis, the varimax rotation approach is used to explain the relationships between factors (Ersoy et al., 2023). In this study, the requirements were an eigenvalue > 1 and a minimum factor loading of 0.5. The researcher used EFA where there was no prior information or hypotheses about which set of indicators should be grouped into variables. Therefore, the researcher starts from the indicators (manifest) and then forms the variables. This instrument is also in a condition where the latent variables have unclear indicators. One indicator could overlap with another (Zeynivandnezhad & Kanooni, 2019).

3. Results

3.1. Content Validation

The content validity of each statement item is shown in Table 1. The content validity value of each item is compared with the critical table value of 0.88. If Aiken's value is greater than 0.88, then the item is considered usable. Table 1 shows that out of the 27 items, the results of Aiken's V analysis were declared 'very good', making them acceptable, and all were considered suitable for the factorial analysis stage to determine the factor structure of the instrument.

Figure 1 shows that there are items that received an average rating of 4.75 by the raters, specifically items 2 and 27. Item 2 asks, 'I develop a teaching plan for the Mathematics Learning Objective Flow on the basis of an analysis of students' initial abilities.' The raters have given their assessment in line with the preparation of a teacher in teaching, which involves developing a flow plan for teaching mathematics in elementary school. For item 27, 'I innovate in the differentiated learning process (content, process, and product) according to the learning style of students.' The raters recommended that this item is crucial in differentiated learning, meaning that teachers must innovate in learning (content, process, and product) tailored to the learning needs of students.

3.2. Exploratory Factor Analysis (EFA)

From the construct developed into survey items, a total of 27 items were obtained. The steps taken before conducting the EFA include iteration with Bartlett's test of sphericity and the Kaiser–Meyer–Olkin (KMO) sampling adequacy measure. The KMO test is applied to assess the adequacy of sampling for each variable in the structure, whereas the Bartlett test is used to determine the significance of correlations among research variables (Capinding, 2023). For the KMO test, the KMO value ranges between 0 and 1 to indicate sample adequacy, whereas the Bartlett test aims to test the hypothesis that the population correlation matrix is an identity matrix (i.e., the variance among variables is zero). Therefore, the null hypothesis in the Bartlett test is that the population correlation matrix is an identity matrix. In line with Watkins (2018), the significance level of the p value should be less than 0.05 to indicate sufficient correlation between variables. A significant result in Bartlett's test (low p value) indicates that the correlation matrix is not an identity matrix, making the data suitable for factor analysis (Ersoy et al., 2023). Both the KMO test and Bartlett's test are very important for exploratory factor analysis. A high KMO value and significant results from Bartlett's test support the adequacy of the sample and the suitability of the data for factor analysis.

Table 2 shows the results of the KMO suitability test for the 27 items at 0.918. This is also affirmed by (Hair et al., 2010), who reported that a KMO value between 0.8 and 1 indicates very high sample adequacy and can be continued with EFA. The Bartlett test produced a value of $\chi^2 = 1944.1$; $p<0.00$. A significant result (p value < 0.05) indicates that the population correlation matrix is not an identity matrix and is suitable for factor analysis. In this case, the significance value is very low (< 0.00), thus rejecting the null hypothesis. This finding supports the suitability of the data for exploratory factor analysis, indicating that the significance level of 0.000 is very significant.

The correlation matrix between variables shows a correlation value of 0.00 for all, indicating that these factors do not correlate with each other. This can be interpreted to mean that each factor does not explain the same or similar variation as other factors in the model. The next step involves calculating the eigenvalue to determine the number of factors formed on the basis of the adequacy of the eigenvalue above 1. The scree plot shows the exploratory factor for teacher readiness in differentiated learning. A gradual slope is observed at the 3rd factor. On the basis of the scree plot test, 3 factors are obtained with an adequacy value above 1, as shown in Figure 2. For more detail, to understand the factor loading value of each factor, refer to Table 2.

Since both assumptions of EFA are met, it can be concluded that factorial analysis is suitable for these data. The results of the analysis indicate that Items B_1 and B_19 were removed after applying EFA via varimax rotation because their factor loading values were less than 0.5. After the removal of items that did not meet the 0.5 factor loading criterion (yellow block in Table 2), the statistical analysis was rerun. EFA confirmed three factors for teacher readiness in differentiated mathematics learning: MR1 (16 items), MR2 (4 items), and MR3 (7 items). Table 3 shows the magnitude of factor loading for each item and the set of factor groups for teacher readiness in differentiated mathematics learning. MR1 (Learning Management) has factor loading values ranging from 0.385--0.822; for MR3 (Teaching Strategies), the loading value is 0.497--0.851; and for MR2 (Coaching and Continuous Learning), the loading value is 0.501--0.687.

Table 1 Content validity of each item.

		Aiken's V	Interpretation
B1	Before teaching, I prepare a lesson plan for the mathematics teaching module on differentiated learning.	.83	very good
B2	I arrange the teaching plan and the learning objectives flow in Mathematics based on an analysis of students' initial abilities.	1.25	very good
B3	I conduct tests to determine students' initial abilities before starting teaching at the beginning of the semester.	1.08	very good
B4	I assess students' work objectively.	1.08	very good
B5	I provide differentiated Mathematics questions suitable for students' abilities, from an existing question bank that I have already taught.	.92	very good
B6	I am very careful in preparing and explaining Mathematics teaching materials to avoid misconceptions.	1.00	very good
B7	I actively participate in seminars/webinars/other scientific forums for self-development, especially in differentiated learning in Mathematics.	1.16	very good
B8	I implement knowledge from seminars/webinars to improve the quality of differentiated learning that I have attended.	1.08	very good
B9	In my teaching, I try to integrate real-life examples that are relevant to the material.	.92	very good
B10	I strive to share varied lesson materials, referring to relevant sources in accordance with the current curriculum.	1.25	very good
B11	I give students the opportunity to ask questions both during and outside of learning sessions.	1.00	very good
B12	I establish teaching materials based on student characteristics.	1.00	very good
B13	I conduct academic ability tests to assess student characteristics at the beginning of the semester.	1.00	very good
B14	I identify students' learning styles before starting teaching at the beginning of the semester with noncognitive diagnostic assessments.	1.08	very good
B15	I strive to adhere to the planned meetings so that the material is truly completed in that semester.	.92	very good
B16	I collect students' assignments for review/correction and provide feedback (grades) to students.	1.08	very good
B17	I find it difficult to use active learning in preparing for differentiated learning using instructional media in online teaching.	1.00	very good
B18	I use active learning from training, preparing, implementing, and evaluating differentiated learning media according to the given lesson material.	1.00	very good
B19	I try to create my own teaching modules for differentiated learning in Mathematics and learning media if not available at school.	1.08	very good
B20	I form groups in classroom learning (mini-lessons).	1.08	very good
B21	I give individual tasks in the form of homework adjusted to students' abilities (differentiation of products).	1.08	very good
B22	I arrange team projects to obtain information on knowledge, understanding, and skills over one semester.	1.16	very good
B23	I invite students to pray together before starting lessons in class.	1.00	very good
B24	I return students' graded work as feedback for them to see their weaknesses.	1.00	very good
B25	I update information useful for the process of differentiated learning in the classroom.	1.00	very good
B26	I evaluate and reflect on myself after the differentiated learning process and try to improve deficiencies.	1.00	very good
B27	I innovate in the process of differentiated learning (content, process, and product) according to students' learning styles.	1.25	very good

The range of eigenvalues for all factors varied from 1.363--10.943. This finding indicates that the factors within this range contribute significantly to the variance in the dataset. An eigenvalue > 1 suggests that the constructs formed from this model are acceptable (Yong & Pearce, 2013). Table 4 also shows that the highest cumulative variance value is 27%. This result is believed to be due to the extraction method, namely, the maximum likelihood method. However, the variance values and cumulative variance are still acceptable, as they meet the established criteria. The identified factors also demonstrate specificity. The first factor explains 51.5% of the variance, meaning that it has the largest contribution in representing the structure. Although the second and third factors have smaller contributions (27.9% and 20.6%, respectively), they remain important in explaining the total variance as additional aspects necessary in differentiated learning.

A relatively high correlation between factors MR1 and MR3 (0.649) indicates that these two factors share a significant amount of variance. This could mean that they represent constructs or dimensions that are closely related within the data. MR1 and MR2 have a correlation of 0.450. This correlation is lower than those of MR1 and MR3 but still indicates a significant relationship. This finding suggests that while MR1 and MR2 are related, they are not as closely linked as MR1 and MR3 are. This could mean that the factors in MR1 and MR2 capture different dimensions but are still interrelated in a broader context. Moreover, MR3 and MR2 have a weaker relationship than the other factor pairs do (0.342).

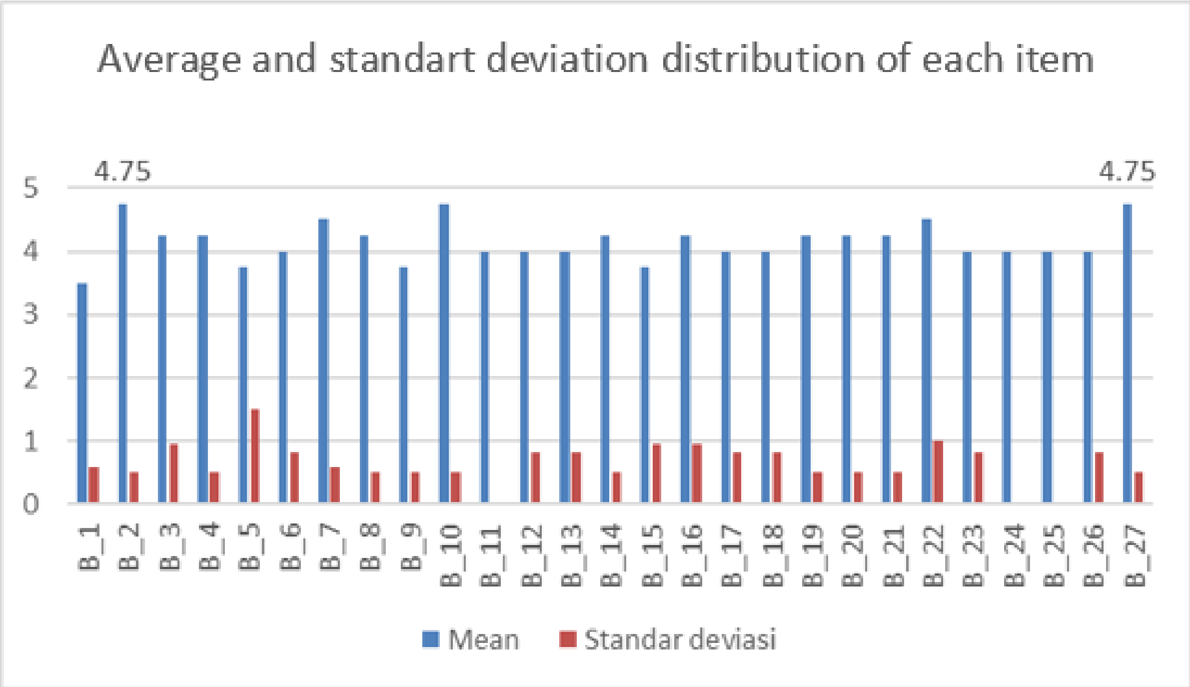

Figure 1 Distribution of Averages and Standard Deviations of Items Measuring Teacher Readiness.

Table 2 KMO and Bartlett's test analysis results.

Kaiser-Mayer-Olkin Measure of Sampling Adequacy		0.918
Bartlett's test of Sperecity	χ^2	1944.1
	df	351
	Sig	<0.00

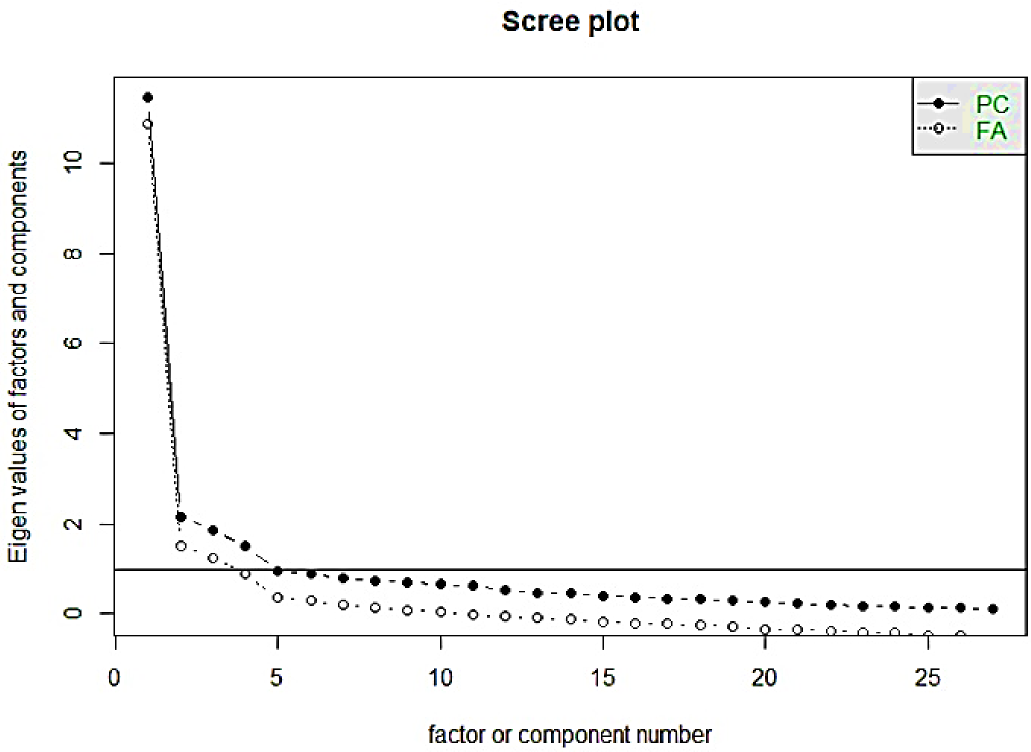

Figure 2 Scree plot of the eigenvalue analysis.

Table 3 Factor loading and variance formed from factor analysis.

Standardized loadings (pattern matrix) based upon correlation matrix						
	MR1	MR3	MR2	h2	u2	com
B_1	0.385			0.466	0.534	2.20
B_2		0.722		0.647	0.353	1.19
B_3		0.600		0.293	0.707	1.24
B_4		0.676		0.503	0.497	1.02
B_5			0.501	0.447	0.553	1.76
B_6		0.569		0.423	0.577	1.07
B_7			0.687	0.618	0.382	1.40
B_8		0.497		0.457	0.543	1.35
B_9		0.851		0.749	0.251	1.10
B_10		0.588		0.620	0.380	1.56
B_11	0.493			0.445	0.555	1.72
B_12			0.519	0.620	0.380	2.02
B_13	0.798			0.557	0.443	1.09
B_14	0.668			0.487	0.513	1.01
B_15	0.603			0.452	0.548	1.15
B_16	0.686			0.568	0.432	1.38
B_17			0.662	0.421	0.579	1.05
B_18	0.570			0.495	0.505	1.17
B_19	0.424			0.513	0.487	2.04
B_20	0.640			0.494	0.506	1.16
B_21	0.666			0.531	0.469	1.31
B_22	0.703			0.555	0.445	1.06
B_23	0.652			0.645	0.355	2.39
B_24	0.461			0.241	0.759	1.05
B_25	0.674			0.589	0.411	1.39
B_26	0.822			0.649	0.351	1.01
B_27	0.699			0.652	0.348	1.48

Table 4 Factor Characteristics of the EFA Results.

Construct	Initial Eigen Value	% of Var.	Cumulative %	Spesificity				
				proportion	Cumulative	Average Inter-Factor Correlation		
						MR1	MR3	MR2
MR1	7.279	27.0	27.0	0.515	0.515	1.000	0.649	0.450
MR3	3.948	14.6	41.6	0.279	0.794	0.649	1.000	0.342
MR2	2.912	10.8	52.4	0.206	1.000	0.450	0.342	1.000

3.3. Data Reliability

The next step involved conducting the Cronbach's alpha reliability test. The Cronbach's alpha reliability test was verified to confirm the accurate dimensions of the factors after EFA was conducted (Table 5). The alpha value for all 27 items was 0.943. According to Bonett and Wright (2015), a Cronbach's alpha coefficient value of more than 0.60 is considered acceptable. Furthermore, a Cronbach's alpha coefficient value approaching 1.0 indicates that the internal consistency of items within the scale is excellent. Specifically, MR1 (Learning Management), with a Cronbach's α of 0.931, indicates very high internal reliability, meaning that the items in this subscale are very consistent in measuring learning management. For MR2 (coaching and continuous learning), a Cronbach's α of 0.764 indicates good reliability but is not as strong as that of MR1. This means that the items in this subscale are fairly consistent in measuring coaching and continuous learning. Finally, MR3 (Teaching Strategies), with a value of 0.866, indicates high reliability, indicating good consistency in measuring teaching strategies. The overall standard deviation (SD) of 0.558, which is lower, indicates greater uniformity in the responses to the items in these subscales.

Table 5 The value of reliability.

Scale Reliability Statistics		
	SD	Cronbach's α
MR1 (learning management)	0.581	0.931
MR2 (coaching and continous learning)	0.783	0.764
MR3(teaching strategies)	0.672	0.866
Overall	0.558	0.943

4. Discussion

This study aims to develop a measure to determine the readiness perceptions of elementary school teachers toward differentiated mathematics learning. In this research, exploratory factor analysis was conducted to assess the construct validity of the scale. This EFA analysis is an analysis of the formation of a hypothesis construct that cannot be directly measured. On the basis of exploratory factor analysis, of the 27 developed items, 2 items, namely, items 1 and 19, were removed because the factor loading value was <0.05. The construction of this instrument on the basis of the theory of differentiated learning resulted in three factors: MR1 (learning management), MR2 (coaching and continuous learning), and MR3 (teaching strategies). The naming of these variables takes into consideration the most dominant similarity in the manifest variables. The correlations between factors are highly significant at values > 0.05; the correlation coefficient between MR1 and MR3 is 0.649; that between MR2 and MR3 is 0.342; and that between MR1 and MR2 is 0.45. The correlation results between factors are not too high (< 0.8), so there is no need to eliminate any factor (Liu et al., 2019; Watkins, 2018), as this correlation does not compete with the reliability of the factor itself. According to (Kline, 2018), the naming of factors is as follows: 1) the naming of factors facilitates only verbal communication, and it cannot be ensured that this hypothesis construct is labeled correctly; 2) factors are also not considered to correspond to something real; and 3) it should not be assumed that if they have the same name, the two are the same. The naming of factors affecting teacher readiness only pertains to their meaningful relationship with external criteria and their ability to replicate in other studies.

Considering the relevant literature, the theoretical framework of elementary school teacher readiness in implementing differentiated mathematics learning supports several dimensions (learning management, coaching and continuous learning, teaching strategies). Moreover, this aligns with the dimensions of studies aiming to understand teachers' perceptions of their readiness for differentiated mathematics learning. In defining differentiated mathematics learning, attention is given to two basic components that form the model: learning management and teaching strategies. Carol Ann Tomlinson offers a profound perspective on differentiated learning, (Tomlinson & Imbeau, 2014) defining differentiated learning as the way teachers design lessons to teach students with varying levels of skill. For her, this means 'teaching with the thought of children' at the center of education (Tomlinson, 2001). There are five teaching elements that, if properly modified, can enhance teaching and learning: the learning environment, curriculum, assessment, and instruction, as well as leadership and classroom management (Tomlinson, 1999).

The most dominant factor, MR1 (learning management), has the highest average factor loading value of 0.652; the principle of differentiated learning itself is the presence of a quality curriculum where the teacher acts as a roadmap to help students achieve their academic goals. It is not just about memorizing facts but also about understanding real-world problems, meaning that mathematics is taught in concrete terms in everyday life (Gusteti & Neviyarni, 2022; Syarifuddin & Matematika, 2022). The group of items in the 'Learning Management' factor reflects various aspects of readiness and implementation of differentiated learning by teachers in the classroom. This is shown in item B_26, with a maximum factor loading value of 0.822, meaning that this item has a very strong correlation with 'learning management.' This finding indicates that this variable excellently represents the factor. Teacher reflection is a key component of differentiated learning. Reflection allows teachers to assess the effectiveness of their approaches and adjust their teaching strategies to better suit the needs of diverse students. This item reflects the importance of reflection in this process (van Geel et al., 2022). Additionally, an emphasis on active learning activities, especially those based on problem solving, is crucial for enhancing students' problem-solving skills. This supports the principle of differentiated learning, where learning activities are tailored to meet the individual learning needs of students and encourage them to actively engage in their own learning process. (Polat & Özkaya, 2023;Kavgacı, 2023). The implication is that teachers contribute to more effective learning management, enabling them to better organize and implement differentiated learning strategies.

The 'Teaching Strategies' factor also provides information on the importance of developing learning strategies in implementing differentiated mathematics learning. This is evidenced by a maximum factor loading of 0.851, which provides theoretical validation of the importance of an item in the 'Teaching Strategies' factor. For example, item B_9 significantly contributes to measuring the 'Teaching Strategies' factor, highlighting the importance of integrating real-life examples in collaboration with various teaching approaches. This is in line with Prahmana's research, which revealed that mathematics learning requires a contextual approach in practice (Prahmana et al., 2020). Previous research also provides evidence that combining learning strategies in mathematics subjects at the elementary level has a significant effect on students (Sunzuma et al., 2021; Boye & Agyei, 2023). In the construct of teacher readiness, teachers have prepared learning with real and active learning approaches in education. Differentiated mathematics learning has a proactive key in the classroom to accommodate different student needs (Kahmann et al., 2022; Tomlinson et al., 2015). This shows that a teacher's strategy is greatly needed by students, who have ideas to initiate students to be active so that they can prepare presentations and discuss ideas with others to develop mathematical thinking skills. Additionally, the importance of teachers' deep understanding of students' ways of thinking and learning in mathematics is a key aspect of differentiated learning. This finding indicates that teachers' readiness to understand and respond to students' mathematical thinking individually and effectively is an important aspect in supporting differentiated mathematics learning (Kükey & Aslaner, 2023; Blanco et al., 2023).

'Coaching and continuous learning' forms the next factor. Although its maximum factor loading of 0.687 is not as high as that of the previous factors, it still makes a significant contribution to this factor. The concept of 'coaching and continuous learning' is an essential element in the professional development of teachers, especially in the context of differentiated learning in elementary schools. Through these activities, teachers gain new knowledge and insights into strategies, methods, and best practices in differentiated learning (Sakti et al., 2023). This is crucial considering the complexity and challenges faced in teaching mathematics in elementary schools, where student learning needs are highly diverse. Differentiated learning in elementary schools requires a flexible and adaptive approach, which can be strengthened through ongoing professional learning. This shows a continuous cycle between professional learning, practical application in the classroom, and improved learning outcomes for students (Sibaen et al., 2023; Licayan et al., 2021). Differentiated learning recommends that teachers develop professionalism to manage learning effectively. In this readiness construct, teachers have already participated in several seminars, workshops, comparative studies, mentoring, or coaching to increase their competence in designing, implementing, and evaluating differentiated learning.

While this study provides valuable insights into teacher readiness for differentiated mathematics instruction, its findings are primarily based on data collected from a specific region (Central Java) and a relatively small sample size. These limitations suggest that caution should be exercised when generalizing the results to other regions or broader educational contexts in Indonesia. Future studies with larger and more diverse samples are recommended to enhance the robustness and applicability of these findings.

The findings highlight the importance of targeted professional development programs that address the three identified factors—Learning Management, Coaching and Continuous Learning, and Teaching Strategies. For instance, teacher training programs could focus on equipping educators with effective classroom management techniques and strategies for differentiated instruction. Additionally, continuous learning initiatives, such as mentorship and peer coaching, could help sustain professional growth and address specific challenges faced by teachers in implementing differentiated learning. Policymakers should also consider providing additional resources and technical support to schools, enabling teachers to adopt innovative instructional methods more effectively.

Future research could explore the long-term impact of professional development initiatives on teacher readiness for differentiated instruction through longitudinal studies. Such research could provide deeper insights into how teacher competencies evolve over time and under varying conditions. Additionally, adapting the readiness scale developed in this study to other subject areas, such as science or language education, could further validate its utility and applicability in diverse educational contexts.

The factors generated from the exploratory factor analysis are interconnected with each other. Each is indicated by the magnitude of the correlation values that emerge from the analysis. This signifies that there is a significant relationship (Table 3). Learning management, as a foundation for effective classroom learning, encompasses aspects of lesson planning, assessing student needs, and organizing material (Onyishi & Sefotho, 2020). Learning management creates a structure and framework that enables the application of more innovative and effective teaching strategies. In this context, coaching and continuous learning provide teachers with the latest knowledge, skills, and strategies needed to enhance their learning management practices. This directly impacts their ability to manage and organize classroom learning more effectively (Unal, 2022). The development and implementation of effective teaching strategies are often driven by the experience and knowledge gained through coaching and continuous learning.

Efficient learning management (MR1) creates an environment where teaching strategies (MR3) can be successfully implemented. Moreover, the experience of implementing these strategies and the challenges that arise in classroom management provide direction and focus for continuous learning and coaching activities (MR2). Conversely, the learning and development gained from MR2 empower teachers to enhance their learning management skills and adopt more effective teaching strategies.

5. Conclusions

Twenty-seven items were distributed to teachers who had implemented the Merdeka curriculum, resulting in 112 responses. The results of the exploratory factor analysis (EFA) show that the items are spread across 3 factors, forming the construction of the instrument to measure teacher readiness at the elementary school level toward differentiated mathematics learning. MR1 (learning management) consists of 14 items, MR2 (coaching and continuous learning) consists of 4 items, and MR3 (teaching strategies) consists of 7 items. The reliability of the instrument construction is indicated by a high Cronbach's alpha coefficient of 0.943. This study represents an important step in understanding teacher readiness for differentiated mathematics instruction under the Merdeka Curriculum. Future research could explore the stability and evolution of these readiness factors over time through longitudinal studies, particularly as teachers gain more experience and professional development opportunities. Furthermore, the developed scale could be adapted and validated for other subject areas, such as science or language education, to assess the broader applicability of differentiated instruction across the curriculum. Such studies would provide comprehensive insights to support targeted interventions and policy improvements in the education sector.

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Ethical considerations

Not applicable.

Conflict of Interest

The authors declare no conflicts of interest.

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