



## Data-Driven Profiling of Teachers’ Competence in Numeracy Instruction: K-Means Clustering Analysis of “Gembira” Training Participants

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| ARTICLE INFO                                                                                                                                                                                                              | ABSTRACT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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| <p>Article history<br/><i>Received: April 2026</i><br/><i>Revised: May 2026</i><br/><i>Accepted: May 2026</i></p> <p>Keywords<br/>K-means clustering,<br/>Mathematical “GEMBIRA”,<br/>Numeracy, Teacher<br/>profiling</p> | <p>Artikel ini bertujuan untuk mengidentifikasi dan mengkategorikan profil kompetensi guru yang mengikuti pelatihan matematika “GEMBIRA” dalam mendukung pengajaran matematika dan memperkuat program literasi numerik di Indonesia. Studi ini menggunakan metode survei kuantitatif dengan pendekatan studi kasus yang melibatkan 2.450 responden guru. Instrumen penelitian didasarkan pada tiga dimensi utama: (1) pola pikir, keterampilan, perangkat, dan sikap profesional; (2) implementasi pembelajaran “GEMBIRA”; dan (3) pemahaman dan implementasi program literasi numerik. Analisis data dilakukan dalam dua tahap. Pertama, analisis deskriptif digunakan untuk mengklasifikasikan kompetensi guru ke dalam empat tingkatan: muncul, berkembang, mahir, dan transformatif. Kedua, analisis kluster K-Means diterapkan untuk mengidentifikasi pola dan mengelompokkan guru berdasarkan kesamaan karakteristik dan kompetensi mereka. Hasil penelitian menunjukkan bahwa sebagian besar guru berada pada tingkat transformatif, diikuti oleh tingkat mahir, sedangkan hanya sebagian kecil yang berada pada tingkat berkembang. Selanjutnya, analisis kluster mengidentifikasi tiga kelompok kompetensi utama: tinggi, menengah, dan dasar. Meskipun mayoritas guru menunjukkan kompetensi yang tinggi, keberadaan kelompok dengan kemampuan menengah dan dasar menunjukkan perlunya upaya peningkatan kapasitas yang terarah. Secara keseluruhan, studi ini menyoroti pentingnya pengembangan profesional berkelanjutan untuk mengoptimalkan implementasi pembelajaran numerasi.</p> <p><i>This article aims to identify and categorize the competency profiles of teachers who participated in the mathematical “GEMBIRA” training in supporting mathematics instruction and strengthening the numeracy program in Indonesia. The study employed a quantitative survey method with a case study approach involving 2,450 teacher respondents. The research instruments were based on three key dimensions: (1) mindset, skillset, toolset, and professional attitudes; (2) implementation of “GEMBIRA” learning; and (3) understanding and implementation of the numeracy program. Data analysis was conducted in two stages. First, descriptive analysis was used to classify teacher competencies into four levels: emerging, developing, proficient, and transformative. Second, K-Means cluster analysis was applied to identify patterns and group teachers based on similarities in their characteristics and competencies. The findings revealed that most teachers were at the transformative level, followed by the proficient level, while only a very small number remained at the developing level. Furthermore, cluster analysis identified three main competency groups: high, medium, and basic. Although the majority of teachers demonstrated high competency, the presence of medium and basic groups indicates the need for targeted capacity-building efforts. Overall, the study highlights the importance of continuous professional development to optimize numeracy learning implementation.</i></p> |



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## INTRODUCTION

Strengthening of numeracy is a strategic agenda in efforts to improve the quality of education (Asri & Maysarah, 2024; Goos et al., 2020). Numeracy is not only defined as the ability to perform arithmetic operations, but also encompasses the ability to understand, interpret, and use mathematical concepts and information in various everyday contexts (Geiger et al., 2015; Sakurai & Goos, 2023). This aligns with the conceptual framework of numeracy, which states that numeracy is a life skill encompassing logical, critical, analytical, and creative thinking, as well as the ability to use data in everyday decision-making (Widdhiarto, Isaeni et al., 2025a). Thus, numeracy skills focus not only on procedural aspects but also on a combination of conceptual understanding of mathematics and its application in real life.

Numeracy skills play a crucial role in helping individuals make rational decisions, solve problems, and understand various phenomena involving quantitative data and information (Geiger et al., 2015; Kemendikdasmen, 2026). As part of 21st-century competencies, numeracy supports students in adapting to rapid scientific and technological developments and participating actively in social and economic life (Nityasanti et al., 2025; Whitney-Smith et al., 2022). Therefore, developing students' numeracy skills is a priority in various educational policies, including through the integration of numeracy into the learning process in schools. Although numeracy has become a strategic agenda in education (Caridah et al., 2024; Hodgen & Noyes, 2026), many schools still struggle to consistently and meaningfully implement numeracy-oriented mathematics instruction (Zulkarnaen & Aziza, 2026). In many cases, mathematics learning remains procedural and teacher-centered, limiting students' opportunities to develop critical thinking and contextual problem-solving skills (Lute, 2023; Nilimaa, 2023; Stephan, 2020). This situation suggests that strengthening numeracy requires not only curriculum reform but also teachers who are capable of implementing meaningful and contextual mathematics instruction.

In the context of school learning, teachers play a very strategic role in developing students' numeracy skills (Kunnari et al., 2021; Ranak et al., 2023; Rosita et al., 2025). Teachers are not only tasked with delivering learning materials but also act as facilitators, designing meaningful and real-life learning experiences (Hassan, 2022; Kusuma et al., 2024). This aligns with deep learning, which has three main characteristics: mindful, meaningful, and joyful (Feriyanto & Anjariyah, 2024; Siregar et al., 2025). Mindful can be interpreted as meaning that students are fully present, both mentally and physically, and focused on the learning process, not just the end result. Meaningful means that learning material is linked to real life and prior knowledge, making it relevant and memorable. Joyful, on the other hand, means that learning is expected to create a positive, challenging, and motivating learning environment, so that students feel valued and emotionally engaged.

In line with the characteristics of in-depth learning, mathematics instruction should not solely focus on mastering procedures and algorithms. However, learning mathematics can encourage students to understand concepts, develop critical thinking skills, and be able to relate mathematical concepts to various contextual situations (Afni & Hartono, 2020; Lestari et al., 2021). So that mathematics, which

has had a conceptual, can automatically begin to be replaced by Hsbollah implemented, even though it cannot change the abstract characteristics of mathematics. Therefore, teacher competence in designing and implementing meaningful mathematics instruction is a crucial factor in supporting the strengthening of numeracy literacy in schools.

Efforts to increase numeracy also require learning that is able to create enjoyable learning experiences and encourage active involvement of students. One of the lessons developed to support more meaningful mathematics learning is “GEMBIRA” learning. This learning is a learning model designed through the five stages: explore contexts (*Gali dan Eksplorasi konteks*), embed content (*Muat konten*), design of learning activities (*Buat aktivitas pembelajaran*), Follow thinking of students’ (*Ikuti alur pikir siswa*), and celebrate and conclude the learning (*Rayakan dan Akhiri pembelajaran*) (Widdhiarto, Prahmana et al., 2025b). At the explore contexts, the teacher encourages students to explore initial knowledge and relate it to real life contexts. At the embed content, The teacher presents mathematical concepts in a structured and meaningful manner and links them to numeracy. Furthermore, in design of learning activities stage, emphasizes active student involvement through various interactive and contextual learning activities. While the celebrate and conclude the learning stage focus on reflection, appreciation and strengthening students' understanding of the material they have studied.

Based on syntax of mathematical “GEMBIRA”, this learning emphasizes the importance of fun, interactive and contextual mathematics learning through the application of various learner-centered learning strategies (Firmansyah et al., 2025). Apart from that, this approach also emphasizes the importance of creating a positive learning environment and developing reflection on the learning process carried out (Widdhiarto, Prahmana et al., 2025b). Through this approach, mathematics learning is expected to be able to increase students' learning motivation while strengthening their understanding of mathematical concepts and numeracy skills in more depth.

The successful implementation learning of “GEMBIRA” in schools is greatly influenced by teacher competence in managing the mathematics learning process. Teacher competence encompasses not only mastery of learning materials but also mindset, skillset, toolset, and professional attitudes in implementing learning practices (Brandt et al., 2022; Gadusova et al., 2019; Kemendikdasmen, 2026; Mabade & Ngobeni, 2024; Zamora & Zamora, 2022). Mindset relates to teachers’ beliefs and perspectives about mathematics learning and the importance of strengthening students’ numeracy skills. Skillset reflects teachers' pedagogical skills in designing and implementing effective learning strategies. Toolset relates to teachers' ability to utilize various learning resources and media to support the teaching and learning process. Meanwhile, a teacher's professional attitude encompasses a commitment to improving the quality of learning, responsibility for consistently carrying out tasks, openness to reflection and improvement of teaching practices, and the ability to collaborate with fellow teachers and others to support learning development. These four aspects are interrelated and form a crucial foundation for supporting the implementation of quality mathematics learning.

To improve teachers' capacity in implementing mathematics learning oriented towards numeracy strengthening, various training programs have been implemented. One such program is the Training of Mathematical “GEMBIRA”, which aims to improve teachers' understanding of mindful, enjoyable and meaningful mathematics learning models and strengthen teachers' abilities in integrating numeracy into the learning process (Kemendikdasmen 2025). This program was implemented in 2025, although there is a possibility that this program will also be implemented in the future. Through the implementation of this program, training of mathematical “GEMBIRA” has provided opportunities for teachers to develop knowledge, skills, and reflection on their learning practices in the classroom (Guru Dikdas, 2025). In addition, teachers are expected to be able to implement mathematics learning that is more contextual, participatory, and oriented towards strengthening students' numeracy skills (Bayu, 2025). Many professional development programs implicitly assume that teachers develop competencies uniformly after participating in training activities. In practice, empirical evidence shows that teachers often exhibit varying levels of understanding, consistency of implementation, and pedagogical transformation after participating in professional development programs. Some teachers may quickly adopt innovative learning practices, while others may still struggle to consistently integrate new approaches into their classroom teaching. This suggests that teacher competency development is heterogeneous, not uniform.

Although various numeracy training programs have been implemented in Indonesia, including the Mathematical “GEMBIRA” training, empirical evidence regarding the heterogeneity of teachers’ competencies after participating in such programs remains limited. Most existing evaluations tend to

focus on teachers' satisfaction, general implementation outcomes, or average competency improvement without identifying distinct competency patterns among teachers (Ananda et al., 2025; Rustiyana, 2023). Consequently, it remains unclear whether teachers develop competencies at similar levels or whether differentiated competency profiles emerge after training participation. This limitation creates challenges for designing differentiated professional development programs that are responsive to teachers' actual needs. Therefore, a data-driven profiling approach is needed to identify variations in teachers' competencies and classify teachers into meaningful competency groups based on their implementation of numeracy-oriented mathematics instruction.

In this context, teacher competency profiles can be analyzed by categorizing them into specific levels. The OECD classifies teacher competency into four levels: novice, developing, proficient, and advanced (Taguma & Barrera, 2019). Similarly, UNESCO (2018) identifies three stages: knowledge acquisition, knowledge deepening, and knowledge creation (transformative stage). Meanwhile, Dreyfus and Dreyfus (1986) propose five levels of skill acquisition: novice, advanced beginner, competent, proficient, and expert. Although many scholars have adapted the five-level model of Dreyfus and Dreyfus (1986) into four levels—namely emerging, developing, proficient, and expert or transformative (Peña, 2010)—this study adopts a four-stage classification consisting of emerging, developing, proficient, and transformative. Conceptually, these four levels are aligned with established frameworks of teacher professional development proposed by OECD (Taguma & Barrera, 2019), UNESCO (2018), Dreyfus and Dreyfus (1986), and Peña (2010).

The four levels of teacher competency in this study emphasizes that teacher competency develops progressively from basic awareness to advanced and transformative practice. In addition, these four levels of teacher competency provide a comprehensive framework for understanding teachers' levels of competency in implementing mathematical "GEMBIRA" learning within numeracy program in the classroom. At the emerging level, participants begin to demonstrate initial awareness of the importance of student-centered learning and numeracy reinforcement, but their understanding and implementation are still basic and inconsistent. At the developing level, participants have a better understanding and are beginning to apply contextual learning strategies, although their implementation is still partial and requires strengthening reflection and more systematic integration. Furthermore, at the proficient level, participants have demonstrated a strong understanding and adequate ability to implement learning consistently, with more varied, contextual strategies, and oriented towards active student involvement. Meanwhile, at the transformative level, participants are not only able to implement learning optimally but also act as agents of change by developing innovations, building collaborations, and conducting in-depth reflection to create sustainable and meaningful learning practices. Understanding these competency levels alone, however, may not fully capture the complexity and heterogeneity of teachers' professional development trajectories.

Although large-scale teacher training programs have been widely implemented, most evaluation studies still rely on aggregate scores that potentially obscure important differences in teachers' competencies. As a result, policymakers may overlook groups of teachers who continue to require targeted professional support. This indicates the importance of analytical approaches capable of identifying heterogeneity among teachers rather than relying solely on average competency scores. In this context, a clustering approach becomes particularly relevant because teacher competency development is rarely linear or uniform. Aggregate descriptive statistics may conceal meaningful differences among teachers, whereas clustering analysis enables the identification of naturally occurring competency groups that can support more targeted and differentiated professional development policies. Such profiling becomes essential for understanding differences in teachers' readiness, pedagogical capacity, and implementation consistency following participation in the Mathematical "GEMBIRA" training program. Furthermore, this approach can provide empirical evidence to support the development of more targeted, differentiated, and needs-based professional development policies and initiatives.

Furthermore, to identify the characteristics of teacher competency patterns in greater depth, a cluster analysis approach was used, specifically the K-Means clustering method. This method is a statistical analysis technique that aims to group data into several clusters based on the level of similarity of characteristics possessed by each subject (Agha et al., 2023; Ahmed et al., 2020). Through this method, subject can be grouped into several clusters that represent different levels of competency (Lund & Ma, 2021), such as groups with high, intermediate, or basic competencies. The results of this grouping

can provide a more comprehensive conceptual framework regarding the distribution of teacher competencies and assist in designing more effective strategies for strengthening teacher capacity.

Therefore, this study aims to address the limited understanding of post-training teacher competency heterogeneity by identifying and classifying teachers' competency profiles using a data-driven clustering approach. Specifically, this study examines variations in teachers' competencies in implementing numeracy-oriented mathematics instruction after participating in the Mathematical "GEMBIRA" training program. By applying K-Means clustering analysis, this study seeks to identify naturally occurring competency groups among teachers and provide empirical evidence for the development of more targeted, differentiated, and needs-based professional development policies in strengthening numeracy instruction in Indonesia. So, the findings are expected to contribute theoretically to discussions on teacher competency heterogeneity, methodologically through the application of K-Means clustering analysis, and practically to the development of differentiated teacher professional development policies in Indonesia.

## METHOD

### Types of Research

This research is quantitative with a case study. A case study is research used to discover or investigate problems in depth about individuals, groups, institutions, social movements, or events, relating to phenomena, context, and time ([Hancock & Algozzine, 2017](#); [Simons, 2014](#)). This study aims to examine the competency profiles of teachers participating in the Mathematical GEMBIRA training program based on several main dimensions, namely (1) mindset, skillset, toolset and professional attitude, (2) implementation of "GEMBIRA" learning, and (3) understanding and literacy of implementation numeracy program.

Furthermore, this study also aims to group teachers based on their competency characteristics using the K-Means clustering method, thus obtaining an overview of the types of teacher competency profiles in implementing mathematics learning and numeracy reinforcement. This study cannot assist in decision-making or reaching conclusions for generalizations ([Bartlett & Vavrus, 2016](#)). However, this study can provide recommendations and descriptions regarding the national numeracy movement program policy that was launched in August 2025 by Ministry of Primary and Secondary Education ([Kemendikdasmen, 2025](#)).

### Participants

Data collection was carried out through an online survey. The questionnaire was distributed using Google Forms, allowing participants to flexibly access and complete the instrument using any internet-connected electronic device. The online survey was chosen because it allows for more efficient data collection, reaches a wider range of respondents, and simplifies the processing of data collected from participants. Furthermore, the online survey was distributed through various online channels, such as WhatsApp groups, social media, and broadcast messages. In order to ensure that the results of the questionnaire completed by participants are reliable, before submitting a response, they are asked to provide a statement "I declare that all the answers I have given in this questionnaire have been filled in honestly, in accordance with my actual understanding, experience and condition".

Based on the results of filling out the questionnaire, it was found that 2,450 teachers participated in training of Mathematical "GEMBIRA". Because researchers cannot control the gender, origin and place of work of respondents, respondents in this study were taken randomly, with a population of all primary Education teachers (preschool, kindergarten, and elementary school). The researcher only limited and ensured that the subjects used in this study were teachers who had participated in training of Mathematical "GEMBIRA" which had been organized by the Directorate of Elementary Education Teachers. The researcher only limited and ensured that the subjects used in this study were teachers who had participated in this training program.

The characteristics of the respondents in this study are described based on several demographic aspects, namely age, teaching level, and distribution of the provinces where the respondents work. This demographic description of the respondents is important to provide an overview of the characteristics of the study population and to help understand the context of the implementation of mathematical "GEMBIRA" learning and numeracy programs at various educational levels and regions. This

demographic information also serves as the basis for interpreting the results of the teacher competency profile analysis obtained in this study. The demographics of the respondents can be seen in Table 1.

Table 1. Demographic of Respondent

| No. | Demographic Types | Age Range                | Total |
|-----|-------------------|--------------------------|-------|
| 1   | Age               | Less than 20 years       | 1     |
|     |                   | 20–24                    | 12    |
|     |                   | 25–29                    | 174   |
|     |                   | 30–34                    | 374   |
|     |                   | 35–39                    | 563   |
|     |                   | 40–44                    | 621   |
|     |                   | 45–49                    | 424   |
|     |                   | 50–54                    | 191   |
|     |                   | 55–60                    | 89    |
|     |                   | Unknown                  | 1     |
| 2   | Level of teaching | Preschool – kindergarten | 1018  |
|     |                   | Elementary school        | 1411  |
|     |                   | Unknown                  | 1     |
| 3   | Provinsi          | Aceh                     | 54    |
|     |                   | North Sumatera           | 86    |
|     |                   | South Sumatera           | 33    |
|     |                   | West Sumatera            | 109   |
|     |                   | Bengkulu                 | 41    |
|     |                   | Riau                     | 43    |
|     |                   | Riau Island              | 44    |
|     |                   | Jambi                    | 35    |
|     |                   | Lampung                  | 92    |
|     |                   | Bangka Belitung Island   | 31    |
|     |                   | West Kalimantan          | 79    |
|     |                   | East Kalimantan          | 48    |
|     |                   | South Kalimantan         | 64    |
|     |                   | Central Kalimantan       | 68    |
|     |                   | North Kalimantan         | 30    |
|     |                   | Banten                   | 68    |
|     |                   | D.K.I. Jakarta           | 119   |
|     |                   | West Java                | 183   |
|     |                   | Central Java             | 175   |
|     |                   | D.I. Yogyakarta          | 76    |
|     |                   | East Jawa                | 101   |
|     |                   | Bali                     | 95    |
|     |                   | East Nusa Tenggara       | 66    |
|     |                   | West Nusa Tenggara       | 105   |
|     |                   | Gorontalo                | 42    |
|     |                   | West Sulawesi            | 40    |
|     |                   | Central Sulawesi         | 50    |
|     |                   | North Sulawesi           | 38    |
|     |                   | Southeast Sulawesi       | 81    |
|     |                   | South Sulawesi           | 182   |
|     |                   | North Maluku             | 32    |
|     |                   | Maluku                   | 35    |
|     |                   | West Papua               | 23    |
|     |                   | Papua                    | 28    |
|     |                   | Central Papua            | 16    |
|     |                   | Highland Papua           | 7     |
|     |                   | South Papua              | 9     |
|     |                   | Southwest Papua          | 21    |
|     |                   | Unknown                  | 1     |

Based on Table 1, it was observed that most respondents were aged between 40 and 44 years and were employed as elementary school teachers. Furthermore, in terms of the distribution of their assigned provinces, respondents came from all provinces in Indonesia, with the three provinces with the largest number of respondents being West Java with 183 participants, South Sulawesi with 182 participants, and Central Java with 175 participants. This fairly wide distribution of respondents shows that the Mathematical “GEMBIRA” training reaches teachers from various regions, thus providing a more representative picture of teacher competency profiles in the implementation of mathematics learning and numeracy programs.

Instrument

The perception profiling scale consists of 30 items that can be grouped based on the dimensions of (1) mindset, skillset, toolset, and professional attitude, (2) implementation of “GEMBIRA” learning, and (3) understanding and literacy of implementation numeracy program. Each dimension is described in several statements that aim to describe respondents' perceptions of practices and competencies in mathematics learning and numeracy reinforcement. The distribution of items for each dimension can be seen in Table 2.

Table 2. A Psychometric Dimension Scale for Perception Measurement

| No. | Dimension                                                     | Total |
|-----|---------------------------------------------------------------|-------|
| 1   | Mindset, Skillset, Toolset and professional attitude          | 10    |
| 2   | implementation of “GEMBIRA” learning                          | 8     |
| 3   | understanding and literacy of implementation numeracy program | 12    |

The alternative answer choices for each statement are arranged using a four-level Likert scale, which represents the respondent's level of agreement with the statement. The scale consists of: (1) strongly disagree, (2) disagree, (3) agree, and (4) strongly agree. The use of this Likert scale allows researchers to measure respondents' attitudes and perceptions more systematically and facilitates the data quantification process for statistical analysis purposes in describing the respondent profile in each dimension studied.

Data Analysis

Data analysis was conducted in two stages. The first analysis was descriptive of the total scores obtained. This analysis aimed to identify respondent profiles based on emerging, developing, proficient, and transformative levels. The tendency levels for each profile—Emerging, Developing, Proficient, and Transformative—can be seen in Table 3.

Table 3. Leveling of Teacher Competency

| Level | Category       | Score Range |
|-------|----------------|-------------|
| 1     | Emerging       | 30 – 52     |
| 2     | Developing     | 53 – 75     |
| 3     | Proficient     | 76 – 97     |
| 4     | Transformative | 98 – 120    |

The four teacher profile levels—emerging, developing, proficient, and transformative—provide a more comprehensive picture of respondents' competency levels in implementing mathematical “GEMBIRA” learning within the numeracy program. Each level has distinct characteristics that reflect their level of understanding, readiness, and consistency in learning practices. The description of each competency profile level is as follows:

1. Level emerging, participants begin to demonstrate initial awareness of the importance of a student-centered learning approach and numeracy reinforcement. However, their understanding and confidence in the Mathematical “GEMBIRA” concept and the implementation of the numeracy program remain rudimentary. Learning practices are inconsistent and tend to follow conventional learning patterns. Participants at this level still require mentoring, conceptual reinforcement, and more concrete examples to implement the learning approach more effectively.

2. Level developing, participants have demonstrated a better understanding of the concept of Mathematical “GEMBIRA” and the importance of reinforcing numeracy in learning. Participants have begun to try implementing various learning strategies that are more contextual and encourage student participation. However, implementation is not yet fully consistent and remains partial. Participants at this stage require reinforcement in terms of reflection on learning practices and support to integrate learning approaches more systematically.
3. Level proficient, participants have a strong understanding and sufficient skills in implementing the Mathematical “GEMBIRA” and numeracy reinforcement in learning. The learning strategies used tend to be more varied, contextual, and oriented towards developing conceptual understanding and active student involvement. Participants also demonstrate the ability to reflect on their learning practices and adapt learning strategies based on student needs. At this stage, participants are relatively ready to implement this approach independently and consistently in learning activities.
4. Level transformative, participants are not only able to consistently implement the Mathematical “GEMBIRA” learning and reinforce numeracy, but also act as agents of change within the school environment or learning community. Participants are able to integrate learning approaches systematically, develop learning innovations, and encourage collaboration with various parties, such as other teachers, parents, and the community. Furthermore, participants at this level demonstrate in-depth reflection skills and contribute to developing more meaningful and sustainable learning practices.

The second analysis was conducted using cluster analysis using K-Means. This analysis aims to identify patterns of similarity in respondent characteristics to obtain participant profile types in the implementation of the Mathematical “GEMBIRA” learning and numeracy program. Cluster analysis is a statistical analysis technique used to group respondents into several groups (clusters) based on the similarity of their response patterns. In other words, this method looks for types or profiles that naturally emerge from the data, without being predetermined by the researcher.

## RESULT AND DISCUSSION

### Result

Teacher Profiling in this study is the overall score obtained by teachers based on 3 dimensions, namely 1) mindset, skillset, toolset, and professional attitude, (2) implementation of GEMBIRA learning, and (3) understanding and literacy of implementation numeracy program. The scores were then categorized based on four predetermined levels: Emerging, Developing, Proficient, and Transformative. Based on the questionnaires completed by 2,450 teachers, the profiling results are as shown in Table 4.

Table 4. The result of Teacher Competency Leveling

| Statistics | Level    |            |            |                |
|------------|----------|------------|------------|----------------|
|            | Emerging | Developing | Proficient | Transformative |
| N          | -        | 3          | 595        | 1852           |
| Score Max. | -        | 74         | 97         | 120            |
| Score Min. | -        | 59         | 78         | 98             |
| Average    | -        | 67         | 92,23      | 112,55         |
| Variance   | -        | 57         | 9,44       | 50,16          |

Based on Table 4, it was found that the majority of respondents were at the Transformative level, namely 1,852 respondents, with an average of 112.55 with a variance in this category of 50.16. This high variance value indicates that the data of respondents at the transformative level is spread close to the lowest score of 98. In addition, there were 595 respondents at the proficient level, with an average score of 92.23, and a variance of 9.44. At the developing level, there were 3 respondents with an average score of 67, a variance of 57. Meanwhile, there were no respondents at the emerging level. These results indicate that in general, respondents have a very good understanding and literacy of the implementation of numeracy programs in supporting reflective, adaptive, and development-oriented mathematics learning practices for students.

Furthermore, to identify patterns of similarity in respondent characteristics, cluster analysis was performed using the K-Means statistical test. This statistic is a non-hierarchical statistical analysis method (non-hierarchical clustering) that aims to group a set of data into k groups (clusters) based on similar characteristics or features. This analysis aims to divide data into clusters, where data in one cluster has a high level of similarity (homogeneous) and has significant differences from data in other clusters (heterogeneous). In this study, the clusters were divided into 3 groups, namely cluster A, cluster B, and cluster C. Based on the K-Means analysis, the results of the cluster centroid (cluster center) were obtained as in Table 5.

Table 5. The Result of Cluster Centroid

| Cluster | Dimension 1 | Dimension 2 | Dimension 3 |
|---------|-------------|-------------|-------------|
| A       | 39.16       | 31.34       | 47.05       |
| B       | 36.50       | 27.99       | 41.16       |
| C       | 31.81       | 24.50       | 36.62       |

The centroid value represents the average score of respondents on each dimension within each cluster, thus describing the general characteristics of each group. The analysis results show differences in the level of achievement of respondents on the three dimensions, forming three groups with distinct characteristics.

Based on Table 5, Cluster A exhibits the highest mean scores across all dimensions, with values of 39.16 for dimension 1, 31.34 for dimension 2, and 47.05 for dimension 3. This indicates that respondents in this cluster have the highest level of understanding and implementation in the aspects of mindset, skillset, toolset, learning implementation, and numeracy literacy. Cluster B has an average value in the middle category with a score of 36.50 in Dimension 1, 27.99 in Dimension 2, and 41.16 in Dimension 3, which indicates that respondents in this group have quite good competencies but are still below the achievement of the highest cluster. Meanwhile, cluster C shows the lowest average value compared to the other two clusters, namely 31.81 in Dimension 1, 24.50 in Dimension 2, and 36.62 in Dimension 3. This indicates that respondents in this cluster have a relatively lower level of achievement in the three dimensions measured. Overall, the results of this grouping indicate a variation in the level of competency of respondents, which can be categorized into high, medium, and basic achievement groups, so that it can be the basis for designing a more targeted capacity building strategy according to the needs of each respondent group. This shows that cluster A is a cluster with a representation of training participants who have very high competencies, Cluster B can be represented by training participants who have medium competencies, and cluster C can be represented by training participants who have basic competencies.

In addition, the K-Means analysis obtained the number of respondents for each cluster as in Table 6.

Table 6. Number of Respondents for Each Cluster

| Cluster | Number of Respondent |
|---------|----------------------|
| A       | 1129                 |
| B       | 633                  |
| C       | 688                  |
| Total   | 2450                 |

Based on Table 6, the number of respondents in each cluster shows a different distribution. Cluster A had the largest number of respondents, namely 1,129 people, followed by Cluster B with 688 respondents, and Cluster C with 633 respondents. The dominance of the number of respondents in Cluster A indicates that most respondents are in the group with higher achievement characteristics on the dimensions analyzed. This indicates that the majority of respondents have a relatively good level of understanding and implementation of the aspects measured in the study. This distribution shows that although most respondents are in the group with a high level of competence, there are still groups of respondents who are in the middle and basic categories. Therefore, the results of this grouping provide an overview of the variation in respondent characteristics that can be used as a basis for designing capacity building strategies or more targeted interventions according to the needs of each respondent group.

Furthermore, for the distribution of clusters based on respondent level (Emerging, Developing, Proficient, and Transformative), the results of the K-Means analysis were obtained as in Table 7.

Table 7. Cluster Distribution Based on Respondent Level

| Cluster | Developing | Proficient | Transformative |
|---------|------------|------------|----------------|
| A       | 0          | 0          | 1129           |
| B       | 0          | 0          | 633            |
| C       | 3          | 595        | 90             |

Table 7 shows that each cluster has a different respondent level composition. Cluster A consists entirely of 1,129 respondents at the Transformative level, with no respondents at the Developing or Proficient levels. This indicates that respondents in this cluster have a very good level of understanding and implementation skills on the dimensions measured in the study. In other words, this group represents respondents who have achieved the highest level of competency. In Cluster B, all respondents are also at the Transformative level, with a total of 633 respondents. Although at the same level as Cluster A, the results of the previous centroid analysis indicate that the average score on the measured dimensions is slightly lower than that of Cluster A. This indicates that respondents in Cluster B still have a high level of competency, but are not as strong as respondents in Cluster A in terms of scores achieved on each dimension.

Unlike the previous two clusters, Cluster C exhibits a greater variety of respondent levels. This cluster is dominated by 595 respondents at the proficient level, followed by 90 respondents at the transformative level, and 3 respondents at the developing level. This composition indicates that the majority of respondents in this cluster are still at the intermediate competency stage and are on their way to a higher level. Therefore, this cluster can be interpreted as a group of respondents who still need capacity building and mentoring to reach the transformative level more evenly.

Discussion

The results of the study indicate that the majority of teachers participating in the Mathematical “GEMBIRA” training are at the transformative level, indicating a very high level of competence in integrating mathematics learning and numeracy reinforcement. This finding is significant when linked to the role of numeracy as an essential 21st-century skill that is not only related to the ability to calculate, but also the ability to think critically, problem-solving (Geiger et al., 2015; Kemendikdasmen, 2026; Nityasanti et al., 2025; Whitney-Smith et al., 2022). In addition, strengthening numeracy also supports data-based decision making in various life contexts (Geiger et al., 2015; Sakurai & Goos, 2023; Widdhiarto, Isaeni et al., 2025a). Thus, the high achievement of teacher competency at the transformative level indicates that teachers have the capacity to implement mathematics learning that is not only procedural, but also meaningful and contextual. This is in line with the results of previous research which shows that teachers with high competence tend to be able to design student-centered learning, integrate real-life contexts, and encourage active involvement and high-level thinking skills in mathematics learning (Nilimaa, 2023; Walters et al., 2014). In addition, other research also reveals that teachers at the advanced competency level have good reflective skills and are able to adjust learning strategies based on the needs and characteristics of students, so that learning becomes more effective and meaningful (Jensen et al., 2016; Poolkrajang, A., & Papanai, 2024).

These findings also strengthen the argument that practice-based and reflection-based training programs, such as the Mathematical “GEMBIRA” training, significantly contribute to improving teachers' professional capacity (Widdhiarto, Prahmana et al., 2025b; Firmansyah et al., 2025). The mathematical “GEMBIRA” learning, which emphasizes fun, interactive, and reflective learning, enables teachers to not only understand concepts but also internalize them in their learning practices (Widdhiarto, Isaeni et al., 2025a). This aligns with the teacher's role as a learning facilitator who designs learning experiences relevant to students' real-life situations (Cahyono & Rusiadi, 2025; Gómez Puente et al., 2013). However, these findings require critical examination, as most previous studies have been limited to measuring competency improvement aggregately and have not explored variations in teacher competency profiles in depth. Therefore, this study fills this research gap by presenting a data-driven approach to identifying the heterogeneity of teacher competencies after training.

Previous studies on teacher competence in numeracy and mathematics education have predominantly focused on measuring pedagogical competence, numeracy teaching ability, technological pedagogical knowledge (TPACK), and reflective teaching practices using descriptive or aggregate approaches (Kadluba et al., 2025; Kaiser & König, 2019; Li et al., 2026). While these studies have contributed significantly to understanding teacher professional development, they generally emphasize average competency achievement and do not sufficiently capture heterogeneity among teachers. In contrast, the present study extends existing literature by applying a data-driven profiling and clustering approach to identify naturally occurring competency groups among teachers. This approach provides a more nuanced understanding of post-training competency variation and offers stronger empirical support for differentiated professional development policies.

Previous studies evaluating mathematics teacher professional development programs have predominantly relied on conventional evaluation approaches such as pretest–posttest designs, descriptive evaluations, and teachers’ perception or satisfaction surveys (Desimone & Garet, 2015; Darling-Hammond et al., 2017). While these approaches are useful for measuring general training effectiveness, they often emphasize aggregate outcomes and provide limited insight into variations in teachers’ competency development after training participation. Consequently, differences in teachers’ learning trajectories, implementation consistency, and professional transformation may remain obscured. In contrast, studies employing data-driven profiling, statistical clustering, or machine learning approaches to identify competency patterns among teachers remain relatively limited, particularly in the context of numeracy-oriented mathematics training programs. Therefore, the present study contributes methodologically by applying K-Means clustering analysis to reveal heterogeneous competency profiles among teachers following participation in the Mathematical “GEMBIRA” training program.

More specifically, the K-Means clustering analysis conducted on three main dimensions: mindset, skillset, and professional toolset, implementation of mathematical “GEMBIRA” learning, and understanding and literacy of numeracy program implementation, yielded three characteristically distinct respondent groups. These results indicate that although the majority of teachers are in the high category in aggregate, there is significant variation in competency achievement among respondents. This confirms that teacher competency is not homogeneous, but rather forms a diverse spectrum based on the level of understanding, experience, and implementation ability.

The first cluster (Cluster A) represents the group with the highest achievement across all dimensions, with all respondents at the transformative level. This indicates that teachers in this group have a strong understanding and excellent implementation skills in “GEMBIRA” learning and the numeracy program. They are not only able to effectively implement learning strategies but also have optimally integrated their mindset, skillset, and toolset into their teaching practices. Theoretically, this group can be positioned as a representation of teachers who have reached the adaptive and reflective professional stage, and even have the potential to become agents of change in the education ecosystem.

Meanwhile, Cluster B shows competency achievement at an intermediate level, although respondents at the transformative level remain dominant. This suggests that while teachers in this group have a fairly good understanding and experience of implementation, there are still gaps in the depth and consistency of learning practices. This finding suggests that level labels do not always reflect uniform competency, necessitating more sensitive analysis, such as clustering, to identify more subtle differences among respondents.

In contrast to these two groups, Cluster C demonstrated relatively lower competency achievement, dominated by respondents at the proficient level and a small proportion at the developing level. This indicates that this group is still in the competency strengthening stage and has not yet fully reached the optimal implementation stage. This indicates that the teacher competency transformation process is gradual and requires ongoing support. Therefore, this group requires more intensive intervention through further training, mentoring, and strengthening professional learning communities.

These findings theoretically provide an important contribution to broadening the understanding that post-training teacher competency is neither linear nor uniform. A cluster-based approach shows that within the same level (e.g., transformative), there is still significant variation in achievement. This challenges conventional approaches to training evaluation, which tend to be aggregative. Therefore, this study introduces a data-driven profiling perspective as a more comprehensive approach to mapping teacher competency. This aligns with previous research stating that teacher competency development is dynamic, contextual, and influenced by various experiential factors and the learning environment

(Darling-Hammond et al., 2017). Furthermore, other studies have confirmed that data-driven approaches and pattern analysis, such as clustering, are more effective in identifying teacher competency heterogeneity than conventional descriptive approaches, thus providing a stronger basis for formulating needs-based teacher professional development policies (Blömeke et al., 2015; Sigrid et al., 2015).

From a practical perspective, the results of this study confirm that teacher professional development cannot be implemented with a one-size-fits-all approach. Teachers in the high-skill cluster can be directed to strengthen good practices and act as mentors or facilitators in learning communities. Meanwhile, teachers in the middle and elementary clusters require more targeted support through advanced training, mentoring, and needs-based capacity building. Therefore, teacher development strategies need to be designed in a differentiated manner to be more effective and targeted. This aligns with previous research showing that effective teacher professional development needs to be tailored to the diverse needs, contexts, and competency levels of teachers. This makes a differentiated and needs-based approach more relevant and impactful (Darling-Hammond et al., 2017; Taguma & Barrera, 2019). Furthermore, other research confirms that adaptive and contextual teacher development programs are more effective in improving the quality of learning practices than general and uniform approaches (Chen et al., 2017; Kaiser & König, 2019).

However, this study also has limitations, particularly the use of self-reported data, which could potentially contain subjective bias. Furthermore, this study did not directly examine classroom learning practices, thus failing to confirm the alignment between perceived competency and actual implementation. Therefore, further research is recommended to use a mixed methods approach or direct observation to obtain a more comprehensive picture.

Overall, this study provides theoretical and methodological contributions to understanding teacher competency profiles in the implementation of mathematics learning and numeracy programs. By integrating descriptive analysis and K-Means clustering, this study not only describes teacher competency levels but also reveals their structure and variation. These findings reinforce the importance of a data-driven approach in education policy formulation, particularly in designing adaptive, contextual, and sustainable teacher professional development programs.

## CONCLUSION

Based on the results of data analysis on 2,450 teachers who have participated in Mathematical “GEMBIRA” training, the majority of respondents are at the transformative level, namely 1,852 respondents, followed by 595 respondents at the proficient level, followed by 3 respondents at the developing level. There are no respondents at the emerging level. These findings indicate that in general, teachers have a strong understanding and good ability to consistently implement the Mathematical “GEMBIRA” and numeracy program in learning. Teachers at the transformative level have even demonstrated the ability to innovate, reflect on learning practices, and act as agents of change in the school environment or learning community.

The results of the K-Means clustering analysis also showed variations in the competency levels of respondents, divided into three groups: the high competency cluster (Cluster A), the medium competency cluster (Cluster B), and the basic competency cluster (Cluster C). Cluster A was the group with the highest achievement in all three dimensions, and all respondents were at the transformative level. Cluster B was also dominated by respondents at the transformative level, but with slightly lower average values for the dimensions. Meanwhile, Cluster C was dominated by respondents at the proficient level, with a small portion at the developing and transformative levels. These findings indicate that although the majority of respondents had achieved a high level of competency, there were still groups of respondents who needed capacity building to improve the quality of numeracy learning implementation more optimally.

## RECOMMENDATION

Based on the results of the analysis and research findings, several recommendations that can be put forward include the following.

1. Continuous teacher capacity building and development are needed, particularly for respondents in the secondary and primary clusters. This can be achieved through advanced training, mentoring in teaching practices, and developing professional learning communities that allow teachers to share good practices in implementing mathematics learning and numeracy reinforcement.

2. Teachers at the transformative level need to be given space to act as mentors, facilitators, or motivators of learning communities in developing mathematics learning in schools and at the regional level. This is crucial for expanding the dissemination of best practices and strengthening a culture of collaboration among teachers to improve the quality of learning.
3. Continuous monitoring and evaluation of the implementation of the GEMBIRA Mathematics approach and numeracy program in schools is necessary. This activity aims to ensure that the knowledge and skills acquired through the Technical Guidance activities can be consistently implemented in learning practices and have a tangible impact on improving the quality of mathematics learning.
4. The results of this profiling can be used as a basis for policy formulation and planning of teacher professional development programs, particularly in strengthening numeracy literacy at various levels of education. By utilizing the results of this teacher competency mapping, capacity development programs can be designed in a more targeted, adaptive manner, and in accordance with actual needs in the field.

## DECLARATIONS

### Author Contribution

RW: Conceptualization, Validation and Supervision; NI: Validation and Supervision; SM: Validation and Supervision; SAW: Writing - Original Draft, Review & Editing, Formal analysis, and Methodology; RCI: Writing - Review & Editing, Validation, and Supervision.

### Conflict of Interest

The authors declare no conflict of interest.

### Declaration of AI Use

This paper was assisted by AI tools, including ChatGPT for translation, text refinement, and coherence enhancement, as well as Grammarly for proofreading. These tools were used to improve readability and adherence to academic standards. The authors are fully responsible for the content and interpretations presented.

### Additional Information

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## REFERENCE

- Afni, N., & Hartono. (2020). Contextual teaching and learning (CTL) as a strategy to improve students mathematical literacy. In *Journal of Physics: Conference Series* (Vol. 1581). <https://doi.org/10.1088/1742-6596/1581/1/012043>
- Agha, D., Meghji, A. F., & Bhatti, S. (2023). Clusters of success: Unpacking academic trends with k-means clustering in education. *VFAST Transactions on Software Engineering*, 11(4), 15-31. <https://doi.org/10.21015/vtse.v11i4.1633>
- Ahmed, M., Seraj, R., & Islam, S. M. S. (2020). The k-means algorithm: A comprehensive survey and performance evaluation. *Electronics*, 9(8), 1295. <https://doi.org/10.3390/electronics9081295>
- Ananda, C., Astaghina, L., & Fauziah, L. (2025). Evaluasi Kinerja Guru. *CARONG: Jurnal Pendidikan, Sosial dan Humaniora*, 2(1), 157-168. <https://doi.org/10.62710/dyw8pt87>
- Asri, M. N., & Maysarah, S. (2024). Differences in High School Students' Numeracy Literacy Skills through Problem-Based Learning and Discovery Learning Models. *Jurnal Riset Pendidikan Matematika*, 11(2), 156-170. <https://doi.org/10.21831/jrpm.v11i2.79084>

- Bartlett, L., & Vavrus, F. (2016). *Rethinking case study research: A comparative approach*. NY: Routledge.
- Bayu, R. (2025). *Pelatihan Matematika GEMBIRA: Mengubah Paradigma Belajar Matematika bagi Guru TK dan SD*. Available at <https://bgtkntb.kemendikdasmen.go.id/?p=987511874>
- Blömeke, S., Hoth, J., Döhrmann, M., Busse, A., Kaiser, G., & König, J. (2015). Teacher change during induction: Development of beginning primary teachers' knowledge, beliefs and performance. *International Journal of Science and Mathematics Education*, 13(2), 287-308. <https://doi.org/10.1007/s10763-015-9619-4>
- Brandt, J. O., Barth, M., Hale, A., & Merritt, E. (2022). Developing ESD-specific professional action competence for teachers: knowledge, skills, and attitudes in implementing ESD at the school level. *Environmental Education Research*, 28(12), 1691-1729. <https://doi.org/10.1080/13504622.2022.2064973>
- Cahyono, D., & Rusiadi, R. (2025). The role of the teacher as a facilitator in the learning process: A review of educational psychology. *International Journal of Teaching and Learning (INJOTEL)*, 3(1), 205-212. Retrieved at <https://injotel.org/index.php/12/article/view/380>
- Caridah, C., Pramono, S. E., Yulianto, A., & Raharjo, T. J. (2024, September). The innovative teaching strategies in numeracy and literacy to achieve SDGS: a systematic literature review. In *Proceedings of International Conference on Science, Education, and Technology* (Vol. 10, pp. 224-230). Retrieved from <https://proceedings.unnes.ac.id/SET/article/view/3872>
- Chen, M., Chiang, F. K., Jiang, Y. N., & Yu, S. Q. (2017). A context-adaptive teacher training model in a ubiquitous learning environment. *Interactive Learning Environments*, 25(1), 113-126. <https://doi.org/10.1080/10494820.2016.1143845>
- Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). Effective teacher professional development. *Learning policy institute*. Retrieved at <https://eric.ed.gov/?id=ED606743>
- Desimone, L. M., & Garet, M. S. (2015). Best practices in teacher's professional development in the United States. *Psychology, Society, & Education*, 7(3), 252-263 <https://doi.org/10.25115/psye.v7i3.515>
- Dreyfus, H.L., & Dreyfus, S.E. (1986). *Mind over Machine: the power of human intuition and expertise in the age of the computer*. Oxford, Basil Blackwell
- Feriyanto, F., & Anjariyah, D. (2024). Deep learning approach through meaningful, mindful, and joyful learning: A library research. *Electronic Journal of Education, Social Economics and Technology*, 5(2), 208-212. <https://doi.org/10.33122/ejeset.v5i2.321>
- Firmansyah, F., Utami, F. D., Arianti, N., Fatimah, I., & Puspita, R. D. (2025). The GEMBIRA Program: A Deep Learning-Based Model to Enhance Literacy Skills in Primary Education. *PrimaryEdu: Journal of Primary Education*, 9(2), 17-29. <https://doi.org/10.22460/pej.v9i2.6220>
- Gadusova, Z., Haskova, A., & Predanocyova, E. (2019). Teachers' professional competence and their evaluation. *Образование и саморазвитие*, 14(3), 17-24. <https://doi.org/10.26907/esd14.3.02>
- Geiger, V., Goos, M. & Forgasz, H. A rich interpretation of numeracy for the 21st century: a survey of the state of the field. *ZDM Mathematics Education* 47, 531–548 (2015). <https://doi.org/10.1007/s11858-015-0708-1>
- Gómez Puente, S. M., Van Eijck, M., & Jochems, W. (2013). Facilitating the learning process in design-based learning practices: An investigation of teachers' actions in supervising students. *Research in Science & Technological Education*, 31(3), 288-307. <https://doi.org/10.1080/02635143.2013.837043>
- Goos, M., Geiger, V., Dole, S., Forgasz, H., & Bennison, A. (2020). *Numeracy across the curriculum: Research-based strategies for enhancing teaching and learning*. NY: Routledge.
- Guru Dikdas. (2025). *Bimtek Calon Fasilitator Matematika Gembira*. Available at <https://gurudikdas.kemendikdasmen.go.id/news/bimtek-calon-fasilitator-matematika-gembira>
- Hancock, D.R., & Algozzine, B. (2017) *Doing Case Study Research: A Practical Guide For Beginning Researchers*. NY: teachers college Press

- Hodgen, J., & Noyes, A. (2026). System-level improvement in mathematics education: re-considering the National Numeracy Strategy in England. *Research in Mathematics Education*, 1-20. <https://doi.org/10.1080/14794802.2026.2628162>
- Hsbollah, H. M., & Hassan, H. (2022). Creating meaningful learning experiences with active, fun, and technology elements in the problem-based learning approach and its implications. *Malaysian Journal of Learning and Instruction (MJLI)*, 19(1), 147-181. <https://doi.org/10.32890/mjli2022.19.1.6>
- Jensen, B., Sonnemann, J., Roberts-Hull, K., & Hunter, A. (2016). Beyond PD: Teacher Professional Learning in High-Performing Systems. Teacher Quality Systems in Top Performing Countries. *National Center on Education and the Economy*. Retrieved at <https://weleadbylearning.org/wp-content/uploads/2017/09/BeyondPDDec2016.pdf>
- Kadluba, A., Strohmaier, A., Schons, C., & Obersteiner, A. (2025). How much C is in TPACK? A systematic review on the assessment of TPACK in mathematics. *Educational Studies in Mathematics*, 118(2), 169-199. <https://doi.org/10.1007/s10649-024-10357-x>
- Kaiser, G., & König, J. (2019). Competence measurement in (mathematics) teacher education and beyond: Implications for policy. *Higher Education Policy*, 32(4), 597-615. <https://doi.org/10.1057/s41307-019-00139-z>
- Kemendikdasmen. (2025). *Siaran Pers: Tindak Lanjut Peluncuran Gerakan Numerasi Nasional, Kemendikdasmen Gelar Bimtek Guru GEMBIRA*. Jakarta: Biro Komunikasi dan Hubungan Masyarakat, Kementerian Pendidikan Dasar dan Menengah Republik Indonesia.
- Kemendikdasmen. (2026). *Naskah Akademik Gerakan Numerasi Nasional*. Jakarta: Badan Standar, Kurikulum, dan Asesmen Pendidikan, Kementerian Pendidikan Dasar dan Menengah Republik Indonesia.
- Kunnari, I., Tuomela, V., & Jussila, J. (2021). Teacher-facilitators' job-crafting: Making meaning and relevance in authentic learning environments. *International Journal of Management, Knowledge and Learning*, 10(1), 115-126. <http://dx.doi.org/10.53615/2232-5697.10.115-126>
- Kusuma, D. A., Delima, N., Widodo, S. A., & Dwipriyoko, E. (2024). Implementation Of Ethnomathematics Using the Trello Application to Increase Students' Numeracy and Digital Literacy. *IndoMath: Indonesia Mathematics Education*, 7(1), 13-19. <http://dx.doi.org/10.30738/indomath.v7i1.86>
- Lestari, F. P., Ahmadi, F., & Rochmad, R. (2021). The implementation of mathematics comic through contextual teaching and learning to improve critical thinking ability and character. *European Journal of Educational Research*, 10(1), 497-508. <https://doi.org/10.12973/eu-jer.10.1.497>
- Li, M., Vale, C., Tan, H., & Blannin, J. (2026). Technological pedagogical readiness: Examining TPACK, educational ecosystem, and teacher attitudes in Chinese primary mathematics education. *International Electronic Journal of Mathematics Education*, 21(2), em0880. <https://doi.org/10.29333/iejme/18282>
- Lund, B., & Ma, J. (2021). A review of cluster analysis techniques and their uses in library and information science research: k-means and k-medoids clustering. *Performance Measurement and Metrics*, 22(3), 161-173. <https://doi.org/10.1108/PMM-05-2021-0026>
- Lute, M. M. (2023). The Impact of High School Math Teachers' Conceptions of Teaching and Learning on Implementation of Student-Centered Instructional Practices. *Doctoral Dissertations and Projects*. 4292. <https://digitalcommons.liberty.edu/doctoral/4292>
- Mabade, A. S., & Ngoben, N. C. (2024). Developing Student-Teachers Attitude and Mindset of a Professional Through School-Based Experience Programme: An Evaluation Research Approach. *e-BANGI Journal*, 21(2). <https://doi.org/10.17576/ebangi.2024.2102.29>
- Nilimaa, J. (2023). New examination approach for real-world creativity and problem-solving skills in mathematics. *Trends in Higher Education*, 2(3), 477-495. <https://doi.org/10.3390/higheredu2030028>

- Nityasanti, N., Laila, A., Saida, A., Baharudin, B., & Yasin, M. H. M. (2025). 21st century learning: A research analysis of numeracy literacy trends among students. *IJORER: International Journal of Recent Educational Research*, 6(1), 264-277. <https://doi.org/10.46245/ijorer.v6i1.726>
- Peña, A. (2010). The Dreyfus model of clinical problem-solving skills acquisition: a critical perspective. *Medical education online*, 15(1), 4846. <https://doi.org/10.3402/meo.v15i0.4846>
- Poolkrajang, A., & Papanai, R. (2024). Reflective Thinking on Enhancing Student Competencies in Learning Management through Outcome-Based Learning According to Constructive Alignment. *International Journal of Engineering Pedagogy*, 14(6). <https://doi.org/10.3991/ijep.v14i6.48409>
- Ranak, L., Rustam, R., & Ero, P. E. L. (2023). Evaluation and effects of STEAM-PBL on mathematics interest and numeracy skills on elementary school. *Jurnal Riset Pendidikan Matematika*, 10(2), 199-210. <https://doi.org/10.21831/jrpm.v10i2.67251>
- Rosita, C. D., Setiyani, S., & Cartini, N. (2025). Integrated Problem Based Learning Differentiated Instruction: An Effort to Improve Students' Literacy Numeracy Skills. *IndoMath: Indonesia Mathematics Education*, 8(1), 33-43. <http://dx.doi.org/10.30738/indomath.v8i1.131>
- Rustiyana, R. (2023). Efektivitas Komunitas Belajar (Kombel) Sekolah dalam Meningkatkan Kompetensi Pedagogik Guru SMP. *Kinanti: Jurnal Karya Insan Pendidikan Terpilih*, 1(2), 148-156. <https://doi.org/10.62518/2vbb1w02>
- Sakurai, J., & Goos, M. (2023). Revisiting tools in numeracy learning: the role of authentic digital tools. *Frontiers in Education* 8. <https://doi.org/10.3389/feduc.2023.1291407>
- Sigrid, B., Jan-Eric, G., & Shavelson Richard, J. (2015). Beyond dichotomies: Competence viewed as a continuum. *Zeitschrift für Psychologie*, 223, 3-13. <https://doi.org/10.1027/2151-2604/a000194>
- Simons, H. (2014). Case Study Research: In-Depth Understanding in Context. In *The Oxford handbook of qualitative research*, Patricia Leavy (ed). Oxford University.
- Siregar, T., Fauzan, A., Yerizon, Y., & Syafriandi, S. (2025). Designing mathematics teaching through deep learning pedagogy: Toward meaningful, mindful, and joyful learning. *Journal of Deep Learning*, 188-202. <https://doi.org/10.23917/jdl.v1i2.11969>
- Stephan, M. (2020). Teacher-centered teaching in mathematics education. In *Encyclopedia of mathematics education* (pp. 836-840). Cham: Springer International Publishing. [https://doi.org/10.1007/978-3-030-15789-0\\_150](https://doi.org/10.1007/978-3-030-15789-0_150)
- Taguma, M., & Barrera, M. (2019). *OECD future of education and skills 2030: Curriculum analysis*. Directorate For Education And Skills Education Policy Committee. Available at <https://read.oecd-ilibrary.org/content/dam/oecd/en/about/projects/edu/education-2040/publications/commissioned-papers/Tichnor-Wagner,%20A.pdf>
- Unesco. (2018). *ICT Competency Framework for Teachers*. Available at [https://teachertaskforce.org/sites/default/files/2020-07/ict\\_framework.pdf](https://teachertaskforce.org/sites/default/files/2020-07/ict_framework.pdf)
- Walters, K., Smith, T. M., Leinwand, S., Surr, W., Stein, A., & Bailey, P. (2014). An Up-Close Look at Student-Centered Math Teaching: A Study of Highly Regarded High School Teachers and Their Students. *Nellie Mae Education Foundation*. Retrieved at <https://www.air.org/sites/default/files/downloads/report/An-UpClose-Look-at-Student-Centered-Math-Teaching.pdf>
- Whitney-Smith, R., Hurrell, D., & Day, L. (2022). The Role of Mathematics Education in Developing Students' 21st Century Skills, Competencies and STEM Capabilities. *Mathematics Education Research Group of Australasia*.
- Widdhiarto, R., Isaeni, N., Mayangwuri, S., Pramudiani, P., Prahmana, R.C.I., Widodo, S.A. (2025a). *Pembelajaran Matematika Yang Menggembirakan*. Jakarta: Direktorat Guru Pendidikan Dasar, Kementerian Pendidikan Dasar dan Menengah Republik Indonesia
- Widdhiarto, R., Prahmana, R. C. I., Isaeni, N., Widodo, S. A., Mayangwuri, S., & Pramudiani, P. (2025b). The theoretical framework of GEMBIRA learning model: An impactful insight for Indonesian numeracy movement. *Union: Jurnal Ilmiah Pendidikan Matematika*, 13(3), 721-733. <https://doi.org/10.30738/union.v13i3.20353>

- Zamora, J. T., & Zamora, J. J. M. (2022). 21st century teaching skills and teaching standards competence level of teacher. *International Journal of Learning, Teaching and Educational Research*, 21(5), 220-238. <https://doi.org/10.26803/ijlter.21.5.12>
- Zulkarnaen, R., & Aziza, A. K. (2026). Teachers' Roles in Designing and Implementing Numeracy-Oriented Instruction in Junior High School Mathematics: A Multiple Case Study. *Journal of Mathematics Instruction, Social Research and Opinion*, 5(1), 809-824. <https://doi.org/10.58421/misro.v5i1.1204>

