



The GROW Strategy for Enhancing Mathematics Teachers' Competence in Designing 21st-Century Learning in the Merdeka Curriculum

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Abstrak

Penelitian ini bertujuan untuk mendeskripsikan kompetensi profesional guru matematika dalam merancang pembelajaran abad ke-21 serta mengkaji peran strategi GROW dalam mendukung pengembangan kompetensi guru pada penerapan Kurikulum Merdeka. Penelitian ini menggunakan pendekatan kualitatif dengan desain fenomenologi yang melibatkan 16 guru matematika dari empat SMP negeri di Kabupaten Batu Bara, Sumatera Utara, yaitu UPT SMPN 1 Tanjung Tiram, UPT SMPN 1 Talawi, UPT SMPN 1 Lima Puluh, dan UPT SMPN 2 Talawi. Data dikumpulkan melalui wawancara mendalam, observasi, dan dokumentasi, kemudian dianalisis melalui reduksi data, penyajian data, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa guru menghadapi tantangan dalam merancang pembelajaran kontekstual dan kolaboratif, mengintegrasikan teknologi digital secara efektif, serta mengembangkan asesmen sesuai kebutuhan peserta didik. Strategi GROW, yang meliputi Goal, Reality, Options, dan Will, menyediakan kerangka reflektif sistematis untuk menetapkan tujuan, mengidentifikasi kondisi nyata, mengeksplorasi alternatif solusi, dan merumuskan komitmen tindak lanjut. Strategi ini mendorong guru merancang pembelajaran secara lebih reflektif, terarah, dan mandiri. Dengan demikian, strategi GROW berpotensi mendukung pengembangan profesional guru matematika dalam merancang pembelajaran abad ke-21 yang selaras dengan Kurikulum Merdeka.

Kata kunci: Guru Matematika, Kompetensi Profesional, Pembelajaran Abad Ke-21, Kurikulum Merdeka, Strategi GROW

Abstract

This study aims to describe mathematics teachers' professional competence in designing 21st-century learning and examine the role of the GROW strategy in supporting teacher development under the Merdeka Curriculum. This qualitative study employed a phenomenological design involving 16 mathematics teachers from four public junior high schools in Batu Bara Regency, North Sumatra: UPT SMPN 1 Tanjung Tiram, UPT SMPN 1 Talawi, UPT SMPN 1 Lima Puluh, and UPT SMPN 2 Talawi. Data were collected through in-depth interviews, observations, and documentation and analyzed through data reduction, data display, and conclusion drawing. The findings revealed that teachers faced challenges in designing contextual and collaborative learning, integrating digital technology effectively, and developing assessments responsive to students' needs. The GROW strategy, comprising Goal, Reality, Options, and Will, provided a systematic reflective framework for establishing development goals, identifying actual conditions, exploring alternative solutions, and formulating follow-up commitments. This strategy encouraged teachers to design learning more reflectively, purposefully, and

independently. Therefore, GROW has the potential to support mathematics teachers' professional development and strengthen their competence in designing 21st-century learning aligned with the Merdeka Curriculum.

Keywords: *Mathematics Teachers, Professional Competence, 21st-Century Learning, Merdeka Curriculum, GROW Strategy*

A. Introduction

Social changes, developments in science, and advances in digital technology in the 21st century have demanded a transformation in education. Learning is no longer oriented solely toward mastery of subject matter but is also directed toward developing critical thinking, creativity, communication, collaboration, digital literacy, and problem-solving skills (Bakar et al., 2025). These changes position teachers as one of the key factors determining the success of the educational process. Teachers are not only required to deliver instructional content but must also possess the competence to design meaningful learning experiences that are relevant to students' needs.

In mathematics education, these demands have become increasingly important because mathematics is not limited to computational skills and mastery of formulas but is also closely related to reasoning, analysis, problem-solving, and decision-making based on available information (Sa et al., 2025). Therefore, 21st-century mathematics learning needs to be designed contextually so that students can connect mathematical concepts with real-life situations. In addition, learning should provide students with opportunities to discuss, collaborate, explore various problem-solving strategies, and appropriately utilize digital technology (No & Kirani, 2026).

The implementation of the Merdeka Curriculum provides teachers with greater opportunities to design learning according to students' characteristics and the context of the educational unit. Teachers are expected to develop learning that is student-centered, flexible, contextual, and oriented toward competency development. In this context, teachers' professional competence is one of the key factors determining the successful implementation of the Merdeka Curriculum (Aswad & Badrun, 2025).

However, curriculum changes and the demands of 21st-century learning also present various challenges for teachers. Not all teachers have the same level of experience and readiness to design learning that integrates 21st-century skills. Some teachers still experience difficulties in developing collaborative learning activities, connecting subject matter with students' real-life contexts, utilizing digital technology pedagogically, and designing assessments capable of comprehensively capturing students' competency development (Fauzan et al., 2022).

These conditions indicate that improving teacher competence cannot be achieved solely through one-way information delivery or conventional training. Teachers need mentoring and reflective processes that enable them to understand their current conditions, identify

professional development needs, determine alternative solutions, and build commitment to change. One strategy that can support this process is the GROW strategy (Mardin et al., 2025).

The GROW strategy is a reflective approach consisting of four stages: Goal, Reality, Options, and Will. The Goal stage helps individuals determine the objectives they seek to achieve. The Reality stage focuses on understanding current conditions, potential, and challenges. The Options stage provides opportunities to explore various alternative solutions, while the Will stage emphasizes establishing commitments and concrete actions to achieve the predetermined goals (Nurmalianti et al., 2024).

In the context of teacher competency development, the GROW strategy can be used as a reflective framework to help teachers evaluate their instructional planning practices. Teachers can identify the competencies they wish to develop, examine current conditions in their instructional practices, consider various alternatives for improvement, and formulate follow-up plans that can be implemented in learning activities (Nurmalianti et al., 2024).

Research on teacher competence in the implementation of the Merdeka Curriculum has been widely conducted. However, studies that specifically explore mathematics teachers' experiences in designing 21st-century learning from a phenomenological perspective while using the GROW strategy as a framework for competency development remain limited and require further investigation (Mubarakah et al., 2024). A phenomenological approach enables researchers to gain a deeper understanding of teachers' experiences, perceptions, challenges, and efforts based on the realities they encounter in their professional practice.

Based on the above considerations, this study aims to describe the professional competence of mathematics teachers in designing 21st-century learning within the implementation of the Merdeka Curriculum, identify the experiences and challenges faced by teachers, and analyze the role of the GROW strategy in supporting the development of mathematics teachers' competence (Suyitno et al., 2025). The findings are expected to contribute to the development of teacher professional development and mentoring strategies, particularly in enhancing teachers' ability to design mathematics learning that is contextual, collaborative, innovative, and integrated with digital technology.

B. Research Method

This study employed a qualitative approach with a phenomenological design to understand the experiences and competencies of mathematics teachers in designing 21st-century learning within the implementation of the Merdeka Curriculum. The study was conducted at the junior high school level in Batu Bara Regency, North Sumatra, Indonesia. The participants were junior high school mathematics teachers who had implemented the Merdeka Curriculum. Participants were selected purposively based on the following criteria: actively teaching mathematics, having experience in developing instructional planning documents, and being willing to provide

in-depth information. School principals or vice principals responsible for curriculum affairs could also be involved as supporting informants.

The object of the study was the professional competence of mathematics teachers in designing 21st-century learning, including the ability to understand students' needs, formulate learning objectives, design contextual and collaborative learning, develop critical thinking and problem-solving skills, integrate digital technology, develop assessments, and reflect on the learning process.

Data were collected through in-depth interviews, observations, and documentation. Interviews were conducted to explore teachers' experiences, understanding, and challenges in designing 21st-century learning. Observations were conducted to examine learning practices and student engagement, while documentation was used to complement the data through the analysis of teaching modules, instructional planning documents, assessments, learning media, and other supporting documents.

The GROW strategy was used as a reflective framework for teacher competency development. The Goal stage was used to determine development objectives, Reality to identify current conditions and challenges, Options to determine alternative solutions, and Will to establish follow-up actions and commitments. Data were analyzed through the stages of data reduction, data presentation, interpretation, and conclusion drawing. Data validity was ensured through source and technique triangulation by comparing data obtained from interviews, observations, and documentation.

C. Result and Discussion

Mathematics Teachers' Competence in Designing 21st-Century Learning

The findings indicate that mathematics teachers have developed a general understanding of the principles of 21st-century learning. However, their understanding has not always been translated into systematic instructional designs that promote critical thinking, creativity, communication, collaboration, and problem-solving. The analysis of interview data, instructional documents, and classroom observations revealed a gap between teachers' conceptual understanding and their practical competence in designing student-centered mathematics learning under the Merdeka Curriculum.

1. Teachers' Understanding of 21st-Century Learning

The interview data indicated that teachers recognized the importance of active participation and problem-solving in mathematics learning. Nevertheless, teachers experienced difficulties in translating these principles into concrete learning activities.

Participant G1 explained:

"Students should not only memorize formulas. They need to understand how mathematics is used in everyday life. However, when preparing the teaching module, I sometimes find it

difficult to develop activities that encourage students to think critically and solve problems independently.” (G1, interview; illustrative quotation).

Similarly, Participant G2 stated:

“I understand that students should be more active in learning. However, I still tend to explain the material first and provide exercises afterward because I am concerned that students will not understand the concepts if they discover them independently.” (G2, interview; illustrative quotation).

These statements illustrate a tension between teachers’ understanding of student-centered learning and their established instructional practices. Although teachers acknowledged the importance of developing students’ higher-order thinking skills, concerns about students’ readiness and conceptual understanding influenced their instructional decisions.

This finding suggests that professional development should address not only teachers’ knowledge of 21st-century learning but also their ability to translate this knowledge into practical instructional designs. This interpretation is consistent with the view that mathematics learning should support the application of mathematical concepts to meaningful and real-world situations (Irfan et al., 2024).

2. Evidence from Instructional Module Analysis

The analysis of instructional modules provided further insight into the gap between learning objectives and classroom activities. In the illustrative document prepared by Participant G1, the learning objective stated:

“Students are able to solve problems involving linear equations in one variable and explain the steps used to obtain the solution.” (Instructional module, G1; illustrative excerpt). However, the corresponding learning activities were described as follows: “The teacher explains the concept of linear equations, provides examples of solving equations, and asks students to complete individual exercises in the textbook.” (Instructional module, G1; illustrative excerpt).

The comparison between the objective and the learning activities suggests that the module emphasized procedural understanding and individual practice. Although these activities may support students’ understanding of mathematical procedures, they provided limited explicit opportunities for collaborative investigation, discussion of alternative solutions, or application of mathematical concepts to contextual problems.

A second illustrative module prepared by Participant G2 included the following activity: “Students work in groups to solve contextual problems related to daily transactions and present their solutions to the class.” (Instructional module, G2; illustrative excerpt).

This activity demonstrated a more explicit connection between mathematical problem-solving, collaboration, and communication. Nevertheless, the quality of the learning design

would also depend on the complexity of the problems, the roles assigned to students, the teacher's facilitation, and the assessment criteria used to evaluate students' reasoning.

The document analysis therefore suggests that teachers may demonstrate different levels of competence in integrating 21st-century skills into mathematics instruction. More importantly, the findings highlight the need to examine the alignment among learning objectives, instructional activities, learning resources, and assessment procedures rather than evaluating instructional modules solely on their administrative completeness.

3. Evidence from Classroom Observations

The illustrative classroom observation records provided additional context for understanding teachers' instructional practices.

During a mathematics lesson on linear equations in one variable, the observation record noted: "The teacher explained the procedure for solving linear equations on the board. Most students followed the worked examples and copied the solution steps into their notebooks. Several students answered questions when directly invited by the teacher, while opportunities for student-to-student discussion were limited." (Classroom observation, G1; illustrative record).

In another illustrative observation, the record stated: "Students worked in small groups to solve a contextual mathematics problem. Some students compared their calculations, while others waited for instructions from more active group members. During the presentation, the teacher asked students to explain how they obtained their answers and encouraged classmates to provide alternative solutions." (Classroom observation, G2; illustrative record).

These observations illustrate differences in the learning opportunities provided by the two instructional approaches. The first emphasized teacher explanation and individual practice, whereas the second created opportunities for mathematical communication and collaboration. At the same time, the second observation suggests that group work alone does not guarantee equal participation or meaningful collaboration. Teachers also need to design appropriate tasks, distribute responsibilities, and facilitate discussions that encourage all students to contribute.

Taken together, the interview accounts, instructional documents, and observation records illustrate how teachers' instructional decisions are influenced by their pedagogical understanding, concerns about student readiness, and familiarity with particular teaching approaches. These findings support the importance of professional development that connects reflection with the practical design and evaluation of mathematics learning.

4. Implications for the GROW Strategy

The identified gap between teachers' conceptual understanding and instructional design competence provides a rationale for applying the GROW strategy as a structured approach to professional development. The strategy consists of four stages: Goal, Reality, Options, and Will or Way Forward.

At the Goal stage, teachers identify specific targets for improving their instructional designs, such as incorporating contextual mathematical problems and providing opportunities for students to explain their reasoning. At the Reality stage, teachers examine their existing instructional modules and classroom practices to identify the strengths and limitations of their current approaches. Interview reflections, document analysis, and observation records can serve as evidence for this process. At the Options stage, teachers explore alternative instructional strategies, including problem-based learning, collaborative mathematical investigations, differentiated tasks, and technology-supported learning activities. At the Will or Way Forward stage, teachers formulate concrete actions for revising their instructional modules, implementing the revised activities, and evaluating their effectiveness.

For example, a teacher whose existing module relies primarily on worked examples and individual exercises could establish a goal of incorporating one contextual problem-solving activity. The teacher could then examine the current module, explore collaborative learning options, and commit to revising the activity and developing an assessment rubric that evaluates reasoning, communication, and problem-solving.

The example illustrates how GROW can connect reflective dialogue with practical instructional planning. However, claims that the strategy actually enhanced teachers' competence must be supported by empirical evidence, such as comparisons of instructional modules before and after the intervention, teachers' reflective accounts, and classroom observations following implementation.

Overall, the findings indicate that enhancing mathematics teachers' competence under the Merdeka Curriculum requires more than improving their understanding of curriculum expectations. Teachers also need structured opportunities to examine their practices, explore alternative instructional approaches, and translate professional learning into concrete changes in instructional design. The GROW strategy offers a potential framework for supporting this process, provided that its implementation and outcomes are systematically documented and evaluated.

Mathematics Teachers' Competence in Designing 21st-Century Learning

The findings indicate that mathematics teachers have a fairly good understanding of the changing paradigm of 21st-century learning. Teachers no longer perceive learning merely as a one-way process of delivering subject matter; rather, they recognize the need to provide students with opportunities to actively construct knowledge, develop thinking skills, communicate, collaborate, and solve problems. This understanding reflects teachers' awareness that the success of mathematics learning should not be measured solely by students' mastery of concepts and ability to solve problems, but also by their ability to apply mathematical concepts in addressing various real-world situations (Irfan et al., 2024).

However, the findings also reveal a gap between teachers' conceptual understanding of 21st-century learning and their ability to translate this understanding into concrete learning designs. Some teachers have been able to formulate learning objectives in accordance with the Learning Outcomes (Capaian Pembelajaran) and students' needs. Nevertheless, in planning practices, these objectives have not always been developed into systematic learning activities that promote critical thinking, creativity, communication, collaboration, and problem-solving skills (Irfan et al., 2024; Yanti et al., 2026).

This condition indicates that teachers' competence in designing learning is not limited to their ability to prepare instructional documents administratively. It also involves their ability to make pedagogical decisions, such as determining appropriate learning experiences, selecting instructional strategies, designing student activities, determining learning resources, utilizing technology, and developing assessments capable of comprehensively capturing students' learning development (Havifah et al., 2025).

Within the context of the Merdeka Curriculum, teachers have greater opportunities to adapt learning to students' characteristics and the conditions of the school environment. This flexibility represents both an opportunity and a challenge. Teachers are required not only to understand the curriculum structure but also to develop learning that is meaningful, contextual, adaptive, and student-centered. Therefore, teacher competency development needs to focus on the ability to design learning experiences rather than merely on the ability to prepare instructional planning documents.

Contextual Learning as a Challenge in Mathematics Learning Design

One of the important findings of this study is that teachers still face challenges in developing contextual mathematics learning. Some teachers have attempted to connect mathematical content with everyday life, particularly by using examples that are familiar to students. This approach helps students recognize that mathematics is not merely composed of formulas, symbols, and problem-solving procedures, but is also connected to various real-life situations (Nurdin et al., 2023).

However, contextualization has not always been implemented comprehensively. In some learning practices, real-life contexts are used merely as an introduction before teachers return to learning patterns centered on content explanation and problem-solving exercises. This condition indicates that context has not yet been fully utilized as the foundation for developing students' thinking processes (Trinova et al., 2026).

Contextual mathematics learning should provide students with opportunities to identify problems, understand relevant information, determine solution strategies, apply mathematical concepts, and evaluate the results obtained. Thus, context should not merely function as an illustration but should become an integral part of the learning experience (Salsabila et al., 2024).

Teachers' challenges in designing contextual learning are associated with several factors. First, teachers need a strong understanding of the characteristics of mathematical content in order to determine appropriate contexts. Second, teachers need to understand students' social backgrounds, environments, and experiences. Third, teachers need to maintain a balance between the use of real-world contexts and the accuracy of mathematical concepts (Sarlin et al., 2025).

These findings indicate that teachers' pedagogical and professional competencies are closely interconnected in the learning design process. Mastery of mathematical content alone is insufficient if teachers are unable to determine how concepts can be learned meaningfully by students. Conversely, an engaging context will also be ineffective if it is not appropriately aligned with learning objectives and conceptual understanding.

Challenges in Designing Collaborative Learning

The findings indicate that mathematics teachers generally recognize the importance of collaborative learning as a key component of 21st-century education. Teachers understand that students need opportunities to cooperate, communicate mathematical ideas, express opinions, consider different perspectives, and solve problems collectively. However, the participants differed in their ability to translate this understanding into structured collaborative learning activities.

Participant G1 described the challenges encountered when organizing group activities: "Usually, I divide the students into groups and give them mathematical exercises to complete together. However, the students who understand the material more quickly often do most of the work, while the others tend to wait for their friends' answers." (G1, interview; illustrative quotation).

This account illustrates a recurring challenge in collaborative mathematics learning: the presence of groups does not necessarily ensure equal participation. Differences in students' mathematical abilities, confidence, and willingness to contribute can influence the distribution of responsibilities within a group. When tasks are not structured to require individual contributions, collaborative activities may become opportunities for a few students to complete the work on behalf of their peers.

A similar pattern was identified in the illustrative classroom observation of G1. The observation record noted that one student took the initiative to write the solution on the board, while two group members watched without contributing mathematical explanations. When the teacher asked the other members to explain the solution, they had difficulty describing the steps used to obtain the answer (classroom observation, G1; illustrative record). This example suggests that teachers need to consider not only whether students work in groups but also

whether each student participates in mathematical reasoning and understands the group's solution.

Participant G2 emphasized a different difficulty, namely the challenge of managing collaborative activities within the available instructional time: "Group discussions can help students exchange ideas, but sometimes they take longer than expected. When the discussion becomes too long, I have difficulty completing all the learning activities planned for that lesson." (G2, interview; illustrative quotation).

This account reveals a variation in teachers' experiences. Whereas G1 emphasized unequal participation, G2 focused on time management and the alignment between collaborative tasks and lesson objectives. These differences indicate that the challenges of designing collaborative learning are multidimensional. They involve the organization of student participation as well as teachers' decisions regarding task complexity, classroom management, and instructional time allocation.

Importantly, the data also need to be examined for negative cases that challenge the dominant pattern. In contrast to the difficulties described above, Participant G3 reported a more positive experience with structured group work: "When I assign each student a specific responsibility, such as identifying information, explaining the strategy, checking the calculations, or presenting the solution, more students become involved. They know what they are expected to contribute to the group." (G3, interview; illustrative quotation).

This contrasting account suggests that unequal participation is not an inevitable feature of collaborative mathematics learning. Instead, the way teachers structure group activities may influence the opportunities students have to participate. Assigning explicit responsibilities can help clarify expectations and encourage students to contribute to the shared task. Nevertheless, this account should not be interpreted as evidence that role assignment always eliminates participation inequalities; its effectiveness also depends on students' understanding of their roles, the nature of the mathematical task, and the teacher's facilitation.

The variation between G1, G2, and G3 is analytically significant. G1 highlighted unequal contributions, G2 emphasized time constraints, and G3 described a strategy that appeared to support more balanced participation. Rather than treating these accounts as contradictory findings, the differences provide a more comprehensive understanding of teachers' experiences. They suggest that collaborative learning depends on the interaction between instructional design, classroom conditions, and teachers' pedagogical decisions. These findings are consistent with the argument that meaningful collaboration requires deliberate planning rather than simply placing students in groups (Yulianti & Multahadah).

Integration of Digital Technology in Mathematics Learning

Another important aspect identified in this study is the utilization of digital technology. The findings show that teachers recognize the importance of technology in supporting 21st-century learning. Technology is used to present instructional materials, provide visual media, deliver exercises, access learning resources, and support instructional communication.

However, the level of technology integration varies among teachers. Some teachers primarily use technology as a presentation aid, such as displaying instructional materials or learning videos. Although such utilization can increase learning variety, it does not necessarily transform students' learning experiences.

In mathematics learning, technology has much broader potential. It can help students visualize abstract concepts, explore patterns, conduct simulations, compare different problem-solving strategies, and test conjectures or hypotheses. Therefore, technology integration should not be based solely on teachers' ability to operate applications but also on pedagogical considerations regarding how technology can support students in achieving learning objectives (Asiyah, 2023).

The findings indicate that one of the teachers' professional development needs is the ability to select and use technology according to the characteristics of the subject matter. Teachers need to consider fundamental questions, such as which technology is relevant to the concept being learned, what learning activities students can perform using the technology, and how technology can improve the quality of students' thinking processes and conceptual understanding (Jufri et al., 2026).

Therefore, the development of teachers' digital competence needs to focus on the integration of technology, instructional strategies, and subject-matter knowledge. Technology will provide greater benefits when it is used to create learning experiences that are difficult or less effective to achieve through conventional approaches.

Challenges in Designing 21st-Century Learning Assessment

In addition to designing learning activities, mathematics teachers face challenges in developing assessment practices that are consistent with the demands of 21st-century learning and the Merdeka Curriculum. In school settings, assessment practices may continue to emphasize students' final answers, scores, and completion of exercises, while providing less explicit attention to mathematical reasoning, communication, collaboration, and problem-solving processes. This situation may occur when teachers have limited time to develop assessment instruments, large numbers of students to assess, or insufficient experience in designing rubrics for evaluating complex learning outcomes.

For example, in a mathematics lesson on systems of linear equations, students may be assessed primarily on whether they obtain the correct numerical solution. Students who use different but mathematically valid strategies may receive similar scores, while the reasoning

behind their answers receives limited attention. Likewise, during group problem-solving activities, teachers may evaluate the final group presentation without systematically identifying each student's contribution or understanding. These situations illustrate the potential gap between assessing mathematical achievement and assessing the broader competencies expected in 21st-century learning.

This challenge can be further illustrated through teachers' experiences. Participant G1 might explain the difficulty as follows: "I usually assess students through exercises and tests because the answers are easier to check. Assessing how students explain their reasoning takes more time, especially when I have to evaluate the work of many students." (G1, interview; illustrative quotation).

Similarly, Participant G2 might describe the difficulty of developing assessment criteria: "I want students to explain their solutions and work together, but I sometimes find it difficult to determine clear criteria for assessing their discussions, individual contributions, and mathematical reasoning." (G2, interview; illustrative quotation).

These illustrative accounts point to two related challenges: the practical demands of assessing large amounts of student work and the pedagogical demands of developing assessment criteria that capture multiple dimensions of learning. The issue is not necessarily that teachers disregard higher-order thinking skills, but that translating these competencies into observable indicators and manageable assessment procedures can be difficult.

The phenomenon can also be examined through the assessment instruments used in schools. For instance, a conventional mathematics test may consist primarily of questions requiring students to calculate numerical answers, with limited opportunities to explain their strategies or interpret results in real-world contexts. An assessment rubric may similarly allocate most of its points to the accuracy of the final answer rather than to problem interpretation, strategy selection, justification, and communication. If such patterns are identified in actual school documents, they would provide concrete evidence of the need to strengthen teachers' competence in designing comprehensive assessment.

In mathematics learning, assessment should provide information not only about whether an answer is correct but also about how students understand problems, select appropriate strategies, justify mathematical procedures, communicate ideas, and reflect on their solutions (Yulianti & Multahadah, 2004). These dimensions are particularly important when students are expected to apply mathematical concepts to unfamiliar situations and explain the reasoning underlying their decisions.

Within the Merdeka Curriculum, assessment needs to be integrated into the learning process. Diagnostic assessment can help teachers identify students' prior knowledge and learning needs. Formative assessment can provide ongoing information about students' progress and inform adjustments to instruction, while summative assessment can evaluate the achievement of

intended learning objectives. The effectiveness of these assessment practices depends on how well teachers align assessment methods with learning objectives and classroom activities.

However, the challenges should not be interpreted as identical across all teachers or schools. Some teachers may already use open-ended questions, performance tasks, peer assessment, or reflective activities to evaluate students' learning processes. Such practices represent an important variation because they demonstrate that assessment focused on broader

Teachers' Experiences in Implementing the GROW Strategy

The implementation of the GROW strategy provides mathematics teachers with a structured opportunity to reflect on their professional competencies and instructional practices. Rather than focusing exclusively on identifying weaknesses, the strategy encourages teachers to clarify development goals, examine their current situations, explore possible solutions, and establish commitments to improve their learning designs.

In the context of the Merdeka Curriculum, teachers are expected to design learning experiences that accommodate students' diverse needs, encourage active participation, integrate meaningful contexts, and develop 21st-century competencies. However, school-based teaching practices may not always reflect these expectations consistently. Teachers may understand the importance of student-centered learning but continue to rely on teacher explanations and routine exercises because of limited preparation time, differences in students' abilities, or uncertainty about designing appropriate activities and assessments.

These conditions provide an important context for understanding teachers' experiences of the GROW strategy. The analysis focuses on how teachers interpret their instructional challenges, identify professional development priorities, and make sense of possible changes to their mathematics learning designs.

The GROW strategy consists of four interconnected stages: Goal, Reality, Options, and Will or Way Forward. The following discussion examines the Goal and Reality stages through illustrative cases that demonstrate how teachers' experiences can be analyzed phenomenologically.

Goal Stage: Determining the Direction of Competency Development

The Goal stage encourages teachers to articulate the professional development objectives they consider important for improving their instructional practices. In school settings, teachers may initially express broad aspirations, such as improving teaching quality, making mathematics more engaging, or implementing the Merdeka Curriculum more effectively. Although these aspirations indicate a willingness to improve, they do not always provide a sufficiently clear direction for instructional development.

A phenomenological examination of teachers' experiences seeks to understand how these general aspirations emerge from the challenges teachers encounter in their everyday

professional lives. For example, a teacher who experiences low student participation during mathematics lessons may begin to recognize that the problem is not simply students' lack of motivation but also the limited opportunities provided for discussion, exploration, and collaborative problem-solving.

In an illustrative case, Participant G1 identified student participation as a priority for professional development:

"I want my students to participate more actively in mathematics lessons. Sometimes, only a few students answer my questions, while the others wait for me to explain the solution. I need to find ways to involve more students in the learning process." (G1, interview; illustrative quotation).

This account illustrates how a general concern about classroom participation can become a more specific professional development goal. Rather than merely aiming to make lessons more interesting, the teacher can establish a concrete objective: designing collaborative mathematical tasks that require every student to contribute an explanation, strategy, or solution.

A different experience may emerge when teachers focus on the use of technology. Participant G2, for example, might identify the difficulty of translating digital resources into meaningful mathematical learning:

"I have used digital presentations to explain mathematical concepts, but I want to learn how to use technology in activities where students can explore problems and explain their own reasoning." (G2, interview; illustrative quotation).

This illustrative account demonstrates a distinction between using technology as a presentation tool and integrating it into learning activities that develop mathematical reasoning. The teacher's goal becomes more purposeful when it is connected to a specific learning need rather than to technology use alone.

These contrasting cases illustrate that teachers' professional development goals may arise from different experiences. Some teachers may prioritize student participation and collaboration, whereas others may focus on contextual learning, technology integration, or assessment design. Such differences are important in phenomenological research because they reveal how teachers interpret their professional responsibilities in relation to their particular classroom experiences.

The Goal stage therefore helps teachers transform broad development aspirations into more specific and meaningful objectives. These objectives can guide subsequent reflection on current practices and the selection of appropriate improvement strategies (Anggriani et al., 2025). The central issue is not simply whether teachers establish goals, but how those goals emerge from their experiences and how they relate to the instructional challenges they seek to address.

Reality Stage: Understanding Current Conditions and Challenges

The Reality stage invites teachers to examine their existing instructional practices, available resources, and professional constraints before selecting possible solutions. In everyday school settings, teachers may be expected to develop instructional modules aligned with the Learning Outcomes, accommodate differences in students' abilities, implement formative assessment, and provide opportunities for active learning. However, the practical conditions in which teachers work may complicate these expectations.

The challenges identified in this stage may include limited preparation time, difficulty selecting contexts that are mathematically meaningful, differences in students' prior knowledge, limited experience with digital learning tools, and uncertainty about assessing students' reasoning and collaboration. These challenges should not be treated as uniform across all teachers. Their significance depends on each teacher's professional experience, school resources, classroom conditions, and existing pedagogical competence (Romdhoni, 2024).

An illustrative case involving Participant G1 demonstrates how the Reality stage can reveal a discrepancy between instructional intentions and actual teaching practices. During reflection, the teacher examined a mathematics lesson designed to develop problem-solving skills. Although the learning objective required students to solve contextual mathematical problems, the instructional module relied mainly on teacher explanations followed by individual exercises.

The teacher reflected: "When I review my teaching module, I realize that I have written problem-solving as one of the learning objectives. However, most of the activities still ask students to follow examples and complete similar questions. I have not provided enough opportunities for them to discuss different strategies." (G1, interview; illustrative quotation).

This case illustrates how reflective examination can help teachers recognize inconsistencies between intended learning outcomes and planned learning experiences. The difficulty is not necessarily a lack of awareness of the curriculum but the challenge of translating curriculum expectations into appropriate instructional activities.

A second illustrative case highlights the influence of students' diverse learning needs. Participant G2 might explain: "When I give a contextual problem, some students can understand the information quickly, but others still struggle to identify what the problem is asking. I often return to explaining the solution because I am worried that some students will be left behind." (G2, interview; illustrative quotation).

This account illustrates the tension between encouraging student independence and ensuring that students receive adequate instructional support. Teachers must consider how to design tasks that maintain meaningful mathematical challenges while providing appropriate guidance for students with different levels of prior knowledge.

A third example concerns assessment. A teacher may design a group problem-solving activity but evaluate students primarily through the final group answer. During reflection, the teacher may recognize that this assessment approach does not clearly indicate whether each student understands the mathematical reasoning or has contributed meaningfully to the discussion. Such a situation demonstrates how instructional activities, student participation, and assessment practices are interconnected.

These examples show how the Reality stage can help teachers identify the specific nature of their challenges rather than interpreting every difficulty as a general lack of competence. Some problems may arise from instructional design decisions, while others may be related to preparation time, classroom composition, technology access, or the availability of learning resources. Distinguishing these factors is essential because different problems require different responses (Mubarokah et al., 2024).

From a phenomenological perspective, the significance of the Reality stage lies in how teachers experience and interpret these situations. Teachers may experience uncertainty when their instructional objectives are not reflected in classroom activities, concern when students struggle with independent problem-solving, or frustration when assessment procedures do not adequately capture students' learning processes. These experiences provide insight into the meanings teachers attach to their professional responsibilities and the challenges of implementing the Merdeka Curriculum.

Consequently, the Reality stage provides a basis for more informed professional development. By examining their existing instructional modules, classroom experiences, assessment instruments, and students' responses, teachers can identify priorities that are grounded in their actual working conditions. This reflective process prepares teachers to explore alternative approaches in the Options stage and establish realistic commitments in the Will or Way Forward stage.

Overall, the Goal and Reality stages illustrate the importance of connecting professional development with teachers' lived experiences. The Goal stage clarifies what teachers wish to improve, while the Reality stage helps them understand the circumstances that shape their current practices. Together, these stages provide a foundation for using the GROW strategy to support more purposeful and context-sensitive mathematics instructional design under the Merdeka Curriculum.

Options Stage: Exploring Alternative Solutions

After identifying goals and understanding current conditions, teachers proceed to the Options stage. At this stage, teachers explore various possibilities for improving their competencies. The findings indicate that alternatives available to teachers include participating in professional development activities, discussing with colleagues, collaborating in the preparation of instructional materials, learning to use digital media, trying new instructional

models, observing instructional practices, and evaluating previously developed learning materials.

The Options stage encourages teachers not to focus solely on limitations. Instead, teachers begin to identify available resources within the school environment and opportunities that can be utilized to support competency development. One particularly promising alternative is collaboration among teachers. In the context of mathematics learning development, collaboration can involve discussing difficult mathematical topics, exchanging instructional materials, planning contextual learning activities, sharing experiences in using technology, and evaluating implemented learning practices (Yanti et al., 2026). Such collaboration is important because professional development does not always have to occur through formal training. The teachers' workplace can become a professional learning environment when a culture of sharing experiences and reflecting on instructional practices is established.

Furthermore, the Options stage encourages teachers to experiment with different approaches gradually. Teachers can select one priority area, implement it in their learning practice, evaluate the results, and then make improvements. This gradual approach allows competency development to take place realistically and sustainably.

Will Stage: Building Commitment to Concrete Action

The Will stage connects reflection with concrete action by encouraging teachers to translate their professional development goals into specific, realistic, and measurable commitments. At this stage, teachers determine what changes they will make, when the changes will be implemented, what resources will be required, and how the outcomes will be evaluated. This stage is particularly important because recognizing instructional problems does not automatically lead to improvements in teaching practice.

In the context of mathematics education under the Merdeka Curriculum, teachers may commit to developing contextual learning materials, implementing problem-based learning, integrating digital media, organizing structured collaborative activities, and designing formative assessments that evaluate students' mathematical reasoning. These commitments should respond directly to the challenges identified during the Reality stage.

An illustrative case involving Participant G1 demonstrates how this process may occur. After identifying that students were accustomed to following worked examples rather than exploring mathematical problems independently, the teacher committed to revising a lesson on linear equations in one variable. The planned changes included introducing a contextual problem, organizing students into small groups, assigning specific responsibilities to group members, and asking students to explain and compare their solution strategies.

The teacher's commitment could be expressed as follows: "In the next mathematics lesson, I will use a problem related to everyday transactions and ask students to solve it in groups. Each

student will have a responsibility, and I will assess not only the final answer but also how students explain their reasoning.” (G1, interview; illustrative quotation).

This example illustrates how a broad goal of improving student participation can be translated into an actionable instructional plan. The commitment specifies the learning activity, the expected student behavior, and the assessment approach. It also provides a basis for evaluating whether the revised design creates more opportunities for students to engage in mathematical reasoning and collaboration.

A second illustrative case concerns the integration of digital technology. Participant G2, who identified difficulties in using technology to support active learning, committed to incorporating a digital visualization tool into a lesson on geometric transformations. Rather than using the technology exclusively to present information, the teacher planned to ask students to manipulate geometric figures, observe changes in their positions, and explain the mathematical relationships they identified.

This commitment could be evaluated through several indicators, including the alignment between the learning objectives and digital activities, students’ explanations of mathematical concepts, and the teacher’s reflection on whether the technology supported understanding. The example demonstrates that technology integration becomes more purposeful when it is connected to a specific mathematical learning objective.

To make these commitments operational, teachers can develop a simple action plan that identifies the intended improvement, the activities to be undertaken, the implementation schedule, and the indicators of progress.

For example, an illustrative action plan may include the following steps:

1. Planning: Revise an instructional module to include a contextual mathematics problem and clearly defined collaborative tasks.
2. Implementation: Conduct the revised lesson and observe students’ participation, mathematical explanations, and interactions.
3. Assessment: Use an assessment rubric to evaluate problem interpretation, strategy selection, mathematical reasoning, communication, and individual contributions.
4. Reflection: Review students’ work and classroom observations to identify which activities were effective and which require further adjustment.

The evaluation process is essential because teachers need evidence to determine whether their commitments have resulted in meaningful changes. For instance, a teacher may discover that assigning group roles increases participation but does not ensure that every student understands the mathematical concepts. This finding would indicate a need to introduce individual follow-up questions, peer explanations, or differentiated support in subsequent lessons.

The Will stage therefore involves not only implementing a planned action but also examining its outcomes critically. Teachers can use revised instructional modules, student work, assessment results, classroom observation records, and reflective journals to evaluate the consequences of their decisions. Such evidence helps distinguish between actions that have been implemented and changes that have actually been demonstrated.

From a phenomenological perspective, this stage also provides an opportunity to explore how teachers experience the process of translating reflection into action. Teachers may experience increased confidence when they successfully implement a revised learning design, or they may encounter uncertainty when students respond differently from what they expected. These experiences are important because they reveal how teachers interpret professional growth and how their understanding of instructional competence develops through practice.

The Will stage can also establish a continuing cycle of professional development. After implementing a revised lesson, teachers return to the Goal stage to identify new priorities based on the evidence collected. For example, if students become more active during group discussions but continue to struggle to justify their mathematical solutions, the teacher may establish a new goal focused on developing students' mathematical argumentation. Overall, the Will stage transforms the GROW strategy from a reflective framework into a process oriented toward practical instructional improvement. By establishing

The GROW Strategy as a Framework for Teacher Professional Development

Based on the overall findings, the GROW strategy can be understood as a reflective framework that supports mathematics teachers' professional development in designing 21st-century learning. Its main strength lies in its ability to actively involve teachers in identifying their needs and determining the direction of their professional development.

The Goal stage helps teachers establish development priorities and directions. The Reality stage helps them understand their current conditions and challenges. The Options stage provides opportunities to explore alternative solutions, while the Will stage encourages teachers to establish commitments and translate reflection into concrete action.

These four stages form an interconnected and continuous process. Teachers begin by setting goals, reflecting on their current conditions, determining strategies, implementing actions, and evaluating the results. Therefore, the GROW strategy can function as a continuous competency development cycle.

Within the implementation of the Merdeka Curriculum, this approach is particularly relevant because teachers are provided with greater flexibility to adapt learning to students' needs and school contexts. Such flexibility requires teachers to make pedagogical decisions reflectively and responsibly (Sa et al., 2025).

The GROW strategy provides a structure that can help teachers utilize this flexibility more systematically. Rather than merely following policy changes or adopting particular instructional strategies because of administrative requirements, teachers can make instructional decisions based on learning objectives, student characteristics, and the actual needs identified in their practices (Bakar et al., 2025).

Conceptually, the relationship between the GROW strategy and teacher competency improvement can be illustrated as follows:

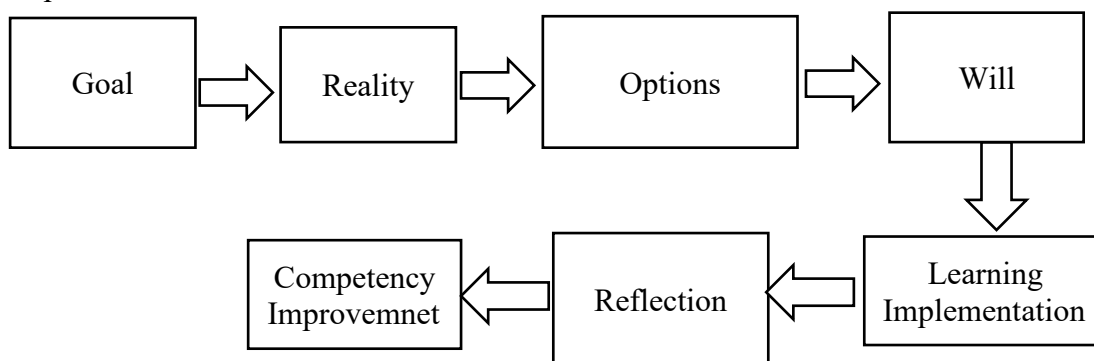


Figure 1. The relationship between the GROW strategy and teacher competency improvement

The relationship between the GROW strategy and mathematics teachers' competency improvement presented in Figure 1 represents a conceptual framework developed by the authors, rather than an independently validated empirical model. The framework was constructed by synthesizing the principles of the GROW coaching model with relevant literature on teacher professional development and interpreting the research findings concerning teachers' experiences in designing 21st-century mathematics learning under the Merdeka Curriculum.

The framework illustrates how the four stages of GROW—Goal, Reality, Options, and Will can provide a structured process for supporting teachers' professional reflection and instructional development. At the Goal stage, teachers identify specific learning-design competencies they seek to develop. At the Reality stage, they examine their existing practices, professional challenges, and contextual constraints. At the Options stage, they explore alternative instructional approaches and assessment strategies. At the Will stage, they establish concrete commitments to implement selected improvements.

Learning implementation and subsequent reflection are incorporated into the framework to illustrate how teachers can examine the consequences of their decisions and identify further development needs. These two components represent the application and evaluation of teachers' action plans, rather than additional stages in the original GROW model. Evidence

obtained through instructional documents, classroom observations, student learning activities, and teachers' reflective accounts can inform decisions about subsequent improvements.

This conceptualization is consistent with the GROW coaching framework, which emphasizes goal setting, examination of current reality, exploration of alternatives, and commitment to action (Whitmore, 2009). It also aligns with literature on reflective practice and professional learning, which emphasizes the importance of examining teaching experiences and using reflection to inform subsequent instructional decisions (Schön, 1983).

Accordingly, Figure 1 should be interpreted as a proposed explanation of how the GROW strategy may support mathematics teachers' competency development, rather than as proof of a causal relationship. Any claim that teachers' competencies improved as a result of implementing the strategy must be supported by empirical evidence demonstrating changes in their instructional planning or teaching practices. The framework therefore serves as a conceptual interpretation that connects the GROW strategy, reflective practice, instructional implementation, and continuous professional development.

Implications of the GROW Strategy for 21st-Century Learning Design

The implications of the GROW strategy for mathematics teachers' professional development need to be understood in relation to the empirical evidence associated with each stage of the model. Rather than assuming that all teachers progress through Goal, Reality, Options, and Will in the same way, the analysis should examine how participants articulate their development goals, interpret their current instructional conditions, consider alternative approaches, and translate their intentions into actual teaching practices.

Mapping Teachers' Experiences across the GROW Stages

At the Goal stage, teachers identify the aspects of instructional design they wish to improve. The illustrative interview data suggest that these goals may include increasing student participation, developing contextual mathematics problems, integrating digital technology, and improving assessment practices. However, identifying a development goal does not necessarily indicate that a teacher has established a feasible plan or implemented a change.

For example, Participant G1 may express the intention to improve collaborative learning but remain uncertain about how to distribute responsibilities among group members. This experience would indicate progress in recognizing a development need while also revealing that further support is required to translate the goal into an actionable instructional design. Such a case is important because it prevents the analysis from equating awareness of a problem with demonstrated professional improvement.

At the Reality stage, teachers examine their existing practices and the conditions that influence their instructional decisions. Evidence from interviews, instructional modules, and classroom observations can be used to identify whether teachers recognize discrepancies

between their intended learning objectives and their actual instructional activities. For instance, a teacher may state that students should develop critical thinking while preparing a module that primarily emphasizes procedural exercises. If this discrepancy is supported by the research data, it provides evidence of reflective awareness of an instructional challenge.

Nevertheless, teachers may differ in the depth of their reflection. Some may identify specific limitations in their instructional modules, whereas others may attribute difficulties mainly to time constraints, student characteristics, or limited resources. These differences indicate that the Reality stage should be examined in terms of how teachers understand their circumstances and whether they identify aspects of their practice that can be changed.

At the Options stage, teachers consider alternative ways of addressing the challenges they have identified. Possible alternatives include contextual problem-solving tasks, structured group activities, differentiated instruction, digital mathematical representations, and formative assessment rubrics. The empirical analysis should distinguish between alternatives that teachers merely mention and those they evaluate, select, or incorporate into revised instructional modules.

For example, if Participant G2 proposes using digital visualization to teach geometric transformations, the interview provides evidence that the teacher has identified a possible alternative. A revised instructional module or an observation of subsequent teaching would provide stronger evidence that this alternative has progressed beyond discussion into practice.

The Will stage requires particular analytical attention because verbal commitment does not necessarily lead to implementation. A teacher may express an intention to revise an instructional module without completing the revision, or may prepare a revised module without implementing it in the classroom. Consequently, evidence of commitment should be distinguished from evidence of action.

For example, a statement such as “I will introduce a contextual problem in the next lesson” demonstrates an intention to act. A revised instructional module can demonstrate that the intended change has been incorporated into the design, while a subsequent classroom observation can establish whether the planned activity was implemented. Students’ work and the teacher’s reflective account may then provide further information about the implementation and its perceived outcomes. These forms of evidence should be interpreted together rather than treating a verbal commitment as proof of improved competence (Nurmaliati et al., 2024).

Variation in Teachers’ Progress through the GROW Stages

The GROW strategy should not automatically be interpreted as a linear process in which all participants complete every stage at the same pace. Teachers may demonstrate different patterns of engagement depending on their prior experience, professional confidence, available resources, and opportunities to implement changes.

An analysis of the data may identify three analytically distinct patterns. The first involves teachers who can identify development goals and recognize their current limitations but have not yet developed or implemented specific solutions. The second involves teachers who identify problems and consider alternative approaches but encounter difficulties when translating those alternatives into classroom practice. The third involves teachers who move from reflection and planning to documented implementation and subsequent evaluation (Fauzan et al., 2022).

These patterns should be reported only if they are supported by the actual research data. They should not be assigned to particular participants solely to illustrate the theoretical model. If a participant's experience does not fit neatly into one pattern, the analysis should preserve that variation rather than forcing the account into a predetermined category.

The distinction is especially important for a phenomenological study because the purpose is to understand the meanings and experiences of participants rather than simply classify them according to the four GROW stages. Differences in teachers' progress can reveal how institutional conditions, instructional responsibilities, and professional experiences shape the ways they engage with reflective development.

Implications for Instructional Design and Professional Development

The empirical mapping of teachers' experiences across the GROW stages has several implications for professional development. First, teachers who can identify goals but struggle to formulate concrete actions may benefit from support in developing measurable instructional objectives and aligning learning activities with those objectives.

Second, teachers who recognize instructional problems but have difficulty identifying solutions may benefit from collaborative lesson planning, peer discussion, and opportunities to examine examples of effective mathematics learning designs. These activities can help teachers explore alternatives that are appropriate to their students and school contexts.

Third, teachers who have developed action plans but have not implemented them may require opportunities to test revised instructional designs, obtain feedback, and reflect on implementation barriers. This distinction demonstrates why professional development should not be evaluated solely through teachers' stated intentions or participation in reflective discussions.

Fourth, teachers who have implemented changes need opportunities to evaluate the evidence and determine what should be retained, revised, or developed further. Evidence may include instructional documents, classroom observations, assessment instruments, student work, and teachers' reflective accounts. These materials can help establish whether planned changes were implemented and what aspects of the learning design may require further improvement.

The findings therefore suggest that the GROW strategy can provide a structured framework for connecting teachers' professional goals with reflection, alternative instructional approaches,

and action planning. However, the extent to which this process results in changes in instructional design depends on whether the different stages are supported by concrete evidence and opportunities for implementation (Suyitno et al., 2025).

Overall, the implications of the GROW strategy should be understood in terms of both its reflective potential and the practical conditions required to translate reflection into action. Teachers' awareness of student-centered, contextual, collaborative, and digitally supported learning is an important starting point, but it does not independently establish that their instructional competence has improved. Such improvement requires evidence of changes in instructional planning and, where relevant, classroom implementation and assessment practices. The GROW strategy may support this process by helping teachers identify their priorities, examine their current practices, consider alternatives, and evaluate subsequent actions within the context of the Merdeka Curriculum.

C. Conclusion

Based on the findings of the study, it can be concluded that mathematics teachers' competence in designing 21st-century learning within the implementation of the Merdeka Curriculum has demonstrated progress in their understanding of student-centered, contextual, collaborative, and digitally supported learning. However, this understanding has not yet been fully accompanied by an optimal ability to translate these principles into systematic and consistent learning designs.

The main challenges faced by teachers include developing mathematics learning contexts that are relevant to students' lives, designing collaborative activities that ensure the participation of every student, integrating digital technology pedagogically, and developing assessments that can comprehensively measure both learning processes and outcomes. These findings indicate that improving teacher competence cannot be achieved solely through mastery of subject matter, understanding of the curriculum, or familiarity with technology. It also requires reflective abilities to continuously evaluate and improve instructional practices.

The GROW strategy contributes as a reflective framework for supporting the professional development of mathematics teachers. The Goal stage helps teachers establish specific development objectives. The Reality stage helps teachers understand their current conditions, strengths, and challenges. The Options stage encourages teachers to explore various alternative solutions and available resources, while the Will stage guides teachers in building commitment and taking concrete actions to improve their learning designs.

Overall, the GROW strategy demonstrates its relevance as a teacher professional development approach that positions teachers not merely as recipients of professional development programs but as active agents who are capable of identifying their needs, reflecting on their practices, determining alternative solutions, and implementing improvement

actions. This process forms a continuous competency development cycle consisting of setting goals, understanding current conditions, determining options, implementing actions, reflecting on outcomes, and improving instructional practices.

Therefore, improving mathematics teachers' competence in designing 21st-century learning within the implementation of the Merdeka Curriculum requires a professional development approach that is reflective, contextual, collaborative, and continuous. The GROW strategy can serve as a relevant alternative for supporting this process because it provides a clear structure for connecting teachers' professional development needs with tangible changes in instructional practice.

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References

- Anggriani, W., Sumarto, S., & Fathurrohman, I. (2025). Pemanfaatan Gemini AI untuk pengembangan LKPD matematika di MAN 1 Lebong. *Jurnal Pendidikan PKMPI*, 1(1), 21–27.
- Asiyah, S. R. (2023). Pengembangan pembelajaran berdiferensiasi untuk meningkatkan kemampuan numerasi siswa SDN Bulukerto 01 Batu. *Jurnal Pendidikan Taman Widya Humaniora*, 2(4), 1–20.
- Aswad, F. H., & Badrun, M. (2025). Manajemen pendidikan implementasi supervisi akademik berbasis coaching dalam meningkatkan kualitas pembelajaran pada Kurikulum Merdeka. *Manajemen Pendidikan*, 20(1), 187–196.
- Bakar, A. A., Bakar, A., & Azizah, A. (2025). Analisis program Merdeka Belajar dalam meningkatkan kualitas pendidikan. *Jurnal Mappesona*, 8(2), 66–75.
- Fauzan, A., Helliensyah, F., Saadiah, H., Ida, S., & Kholid, I. (2022). Strategi guru dalam membangun ketahanan matematika siswa SD pada Kurikulum Merdeka: Sebuah meta-etnografi. *Pedagogy*, 11(1), 240–254.
- Havifah, B., Khosiyono, C., Azizah, D. M., Ariyani, A. I., Nurvina, K., Alifah, L., Kartika, D., Standar, B., & Pendidikan, P. K. (2025). Pelatihan pengembangan media pembelajaran digital storytelling berbasis pendekatan bilingual dengan software Articulate Storyline bagi guru SD di Kabupaten Sleman. *Prima Abdika: Jurnal Pengabdian Masyarakat*, 4(4), 574–584.
- Irfan, M., Gunar, E. R., Kambuno, F. K., Nurmala, I., Aidil, M., Baddolo, M., & Malik, M. A. (2024). Menumbuhkan pemahaman Profil Pelajar Pancasila terhadap guru PKn SMP se-Kota Parepare dalam implementasi Kurikulum Merdeka. *COMSERVA: Jurnal Penelitian dan Pengabdian Masyarakat*, 4(1), 135–144. <https://doi.org/10.59141/comserva.v4i1.1331>

- Jufri, Y., Rustam, A., & Zulaeha, O. (2026). Upaya penguatan keterampilan abad 21 siswa SMP di lingkungan pembelajaran model berdiferensiasi. *JIMAT: Jurnal Ilmiah Matematika*, 7(1), 104–113.
- Mardin, H., Arafat, M. Y., Yusuf, F. M., Mamu, H. D., & Husain, I. H. (2025). Pendampingan guru dalam pengembangan media pembelajaran berbasis augmented reality (AR). *MOPOONUWA*, 2(1), 147–156.
- Mubarokah, H. R., Gabriella, I., Lestari, N. D. S., Kurniati, D., & Yudianto, E. (2024). Implementasi pembelajaran sosial emosional (PSE) dalam Kurikulum Merdeka di MI Unggulan Nuris. *ARITMATIKA*, 5(2), 1–24.
- Nafisa, M. D., & Fitri, R. (2023). Implementasi Kurikulum Merdeka dalam penerapan pembelajaran berdiferensiasi di lembaga PAUD. *Jurnal Studi Guru dan Pembelajaran*, 6(2), 179–188.
- No, V., & Kirani, P. (2026). Strategi pengembangan profesional guru dalam meningkatkan kualitas pembelajaran dalam Kurikulum Merdeka: Studi literatur. *Jurnal Pendidikan dan Keguruan*, 4(3), 281–290.
- Nurdin, D., Murfiah, U., & Amin, A. (2023). Assistance with the implementation of the Independent Curriculum in building Pancasila student profiles for school principals and driving teachers. *Dinamisia*, 7(6), 1769–1778.
- Nurmaliati, N., Oktiawati, U. Y., Ikhlas, A., Kurnia, H., Taufan, A., & Sawlani, D. K. (2024). Kurikulum dan pendidikan berbasis proyek mendorong kreativitas dan kolaborasi. 5, 63–79.
- Romdhoni, M. F. (2024). Peran strategis manajemen kepemimpinan kepala sekolah dalam implementasi Kurikulum Merdeka di Sekolah Penggerak. *Nusantara: Jurnal Pendidikan Indonesia*, 4(4), 1–15.
- Sa, L., Triana, Y., & Weran, I. (2025). Peningkatan kemampuan literasi dan numerasi pada siswa SD melalui media Litnum Spin. *Sn entang: Jurnal Pengabdian Masyarakat Berkelanjutan*, 1, 1–8.
- Salsabila, A., & Yahfizham, Y. (2024). Studi literatur: Analisis berpikir komputasi pada guru dan siswa dalam konteks implementasi Kurikulum Merdeka. *Bilangan: Jurnal Ilmiah Matematika, Kebumian, dan Angkasa*, 2(3), 1–13.
- Sarlin, S., My, N., Nur, M., & Arsyad, F. (2025). Analisis program pengembangan kompetensi guru dalam penerapan Kurikulum Merdeka. *EDUKATIF*, 1(3), 85–94.
- Suyitno, S., Hidayatul, R., Ferlinda, F., Afifa, F., Agustin, D. K., & Nisa, N. L. S. (2025). Transformasi pendidikan melalui Program Kampus Mengajar 8 dengan pendekatan kolaboratif untuk meningkatkan literasi, numerasi, dan adaptasi teknologi di SMP Negeri 2 Pucuk. *Jurnal Abdidas*, 6(1), 33–44.
- Trinova, Z., Nasution, W. R., & Hatta, H. (2026). Implementasi Kurikulum Merdeka dan strategi pembelajaran aktif dalam meningkatkan kompetensi siswa di era pendidikan 4.0. *Berajah Journal*, 6(4), 1833–1844.
- Yanti, D., Kurino, Y. D., & Cahyaningsih, U. (2026). Pengaruh model Realistic Mathematics Education terhadap aspek kognitif pada pembelajaran matematika di sekolah dasar: Systematic literature review. *Buletin Ilmiah Pendidikan*, 5(3), 912–928.
- Yulianti, R., & Multahadah, C. (2004). Discovery learning dalam Kurikulum Merdeka.