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Empowering Physics Teachers in Indonesia through DELIVER: A Community-Based Approach to Reduce Student Misconceptions

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Abstract

Student misconceptions in physics remain a persistent barrier to meaningful learning, often overlooked due to limited teacher training in diagnosis and conceptual remediation. This community service program aimed to enhance the pedagogical capacity of physics teachers in addressing student misconceptions through the DELIVER (Deep Learning-Integrated Verbal Refutation) approach. Implemented using a Community-Based Participatory Research (CBPR) framework, the program involved 237 teachers from various regions in Indonesia, with 69 completing both pre- and post-tests. The training covered deep learning concepts, identification of misconceptions, and practical development of refutation texts. Results indicated significant improvement with normalized gain scores exceeding 0.7 in all concept categories. In addition to cognitive gains, teachers demonstrated reflective shifts in pedagogical awareness regarding the role of misconceptions in learning. A total of 94.12% of participants reported enhanced understanding, and 82.35% expressed readiness to implement the DELIVER approach. In conclusion, the DELIVER approach effectively empowers physics teachers in Indonesia to identify and address student misconceptions, offering a scalable model for professional development in physics and science education. This program contributes to the field by offering a scalable and research-informed model for teacher professional development focused on conceptual change in science education.

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INTRODUCTION

Physics education in Indonesia continues to face complex and multi-layered challenges, one of which is the existence of deeply rooted misconceptions in students' understanding of basic physics concepts (Listianingrum et al., 2024). Despite extensive curriculum reforms and various pedagogical innovations, data from international assessments such as PISA show that the majority of Indonesian students still have low or moderate thinking skills (Susilowati et al., 2022). This phenomenon indicates that the learning approaches currently being implemented are not yet fully capable of fostering comprehensive and applicable conceptual understanding. Globally, similar concerns have been raised, with studies reporting that misconceptions persist even among high-achieving students if instructional approaches are not designed to challenge pre-existing mental

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models (Alexander et al., 2023; Ali et al., 2022; Soysal, 2024). In response to this challenge, deep learning approaches are a potential strategy for creating more meaningful educational transformation (Zebua, 2025). The term 'deep learning' refers to immersive and meaningful learning (Andayanie et al., 2025), not artificial intelligence.

Deep learning is an approach that relies not only on cognitive understanding of concepts but also encompasses the affective and reflective dimensions of the learning process (Andayanie et al., 2025). This model emphasizes the importance of student engagement in critical thinking, connecting ideas, and applying knowledge to real-world situations. In this context, deep learning also encompasses the principles of "mindful", "meaningful" and "joyful" as advocated in the current national curriculum policy. These three principles not only foster mastery of the material but also foster emotional attachment and personal relevance to what students learn (Kemdikdasmen, 2025).

Deep learning does not simply target cognitive achievement in the form of memorization or repetition of information, but emphasizes students' ability to apply knowledge in new situations, think critically about the information received, and actively reflect on their learning process (Rahayu et al., 2025). In the context of physics, deep learning enables students to build a coherent and integrated understanding of the complex laws of nature. To support this approach, professional development programs are needed that are not only instructional but also participatory and contextual. However, the effectiveness of physics learning is strongly influenced by teachers' ability to remediate student misconceptions, which have been consistently identified in empirical studies as one of the most significant obstacles to deep conceptual understanding and sustained conceptual change in physics learning (e.g. Disessa, 2017; Posner et al., 1982).

To effectively realize deep learning, conceptual barriers such as misconceptions need to be addressed seriously and systematically. Misconceptions are particularly problematic because they can obscure students' understanding of fundamental principles that are hierarchical and interconnected (Alabi & Jelili, 2023; Kaniawati et al., 2019; Sarwar et al., 2024). If misconceptions are not promptly addressed, advanced concepts taught in subsequent classes will be built on the foundation of erroneous understanding, leading to further confusion and even resistance to sound scientific knowledge. Furthermore, misconceptions that are not properly addressed not only hinder academic achievement but can also shape erroneous thinking in the long term (Assem et al., 2023; Kaniawati et al., 2021; Pieschl et al., 2021). Many students develop intuitive, yet unscientific, understandings, and unfortunately, these are rarely explicitly addressed in daily learning.

Furthermore, these recurring misconceptions are a major obstacle to the effective implementation of deep learning, and therefore require special attention from teachers. One strategy that has proven effective is the use of refutation texts. Refutation texts is a type of argumentative writing. It begins by stating a common misconception, then refutes it directly, and ends with a correct scientific explanation (Asterhan & Resnick, 2020; Mufida et al., 2023; Samsudin et al., 2025). This format is designed to create cognitive conflict, that is, tension in students' minds between what they believe and what is scientifically true, thus encouraging more meaningful and lasting conceptual change. Refutation texts becomes an important component in this approach because it helps teachers create constructive cognitive conflict in the classroom (Fratiwi et al., 2024; Suhandi et al., 2025; Susilowati et al., 2025).

Refutation texts aligns with the deep learning framework, which prioritizes comprehensive conceptual understanding, the interconnectedness of concepts, and students' emotional and intellectual engagement in the learning process. This connection demonstrates that the use of refutation texts is not merely an additional strategy, but an integral part of a learning ecosystem that encourages transformation in students' thinking. However, many teachers have not received adequate formal training in effective, research-based approaches to addressing misconceptions (Asberger et al., 2021; Rhoney & Meyer, 2024). This gap highlights the need for training interventions that are not merely technical but also encourage teacher reflection and empowerment. Participatory and contextualized professional development programs are essential for teachers to become agents of change in their own classrooms.

Responding to this need, the DELIVER (Deep Learning–Integrated Verbal Refutation) approach was introduced through a structured community service program. Unlike conventional refutation texts that primarily focus on presenting misconceptions and their scientific corrections, DELIVER integrates deep learning principles by guiding teachers through a systematic process of designing context-sensitive refutation texts and reflecting on their pedagogical use to support sustained conceptual change. This approach emphasizes meaning-centered learning, reflective practice, and the interconnectedness of physics concepts, with refutation texts serving as a core strategy for misconception remediation. Therefore, this community service aims to enhance the pedagogical capacity of physics teachers in addressing student misconceptions through the DELIVER approach, particularly by strengthening teachers' ability to design and implement remediation strategies using refutation texts, align instructional explanations with deep learning principles, and engage in reflective pedagogical practices to support conceptual change in physics learning.

METHOD

This community service activity uses a Community-Based Participatory Research (CBPR) approach, which positions teachers as active partners in all stages of the activity (Fratiwi et al., 2025; Page-Reeves, 2019; Tremblay et al., 2017). All stages of training follow the CBPR framework, which consists of: (1) Laying the Foundation, (2) Activity Planning, (3) Information Collection and Analysis, and (4) Follow-up on Findings as shown in Figure 1. This approach was chosen because it aligns with the program's objectives to not only provide one-way training but also develop teacher capacity through a collaborative, reflective, and locally context-based process.

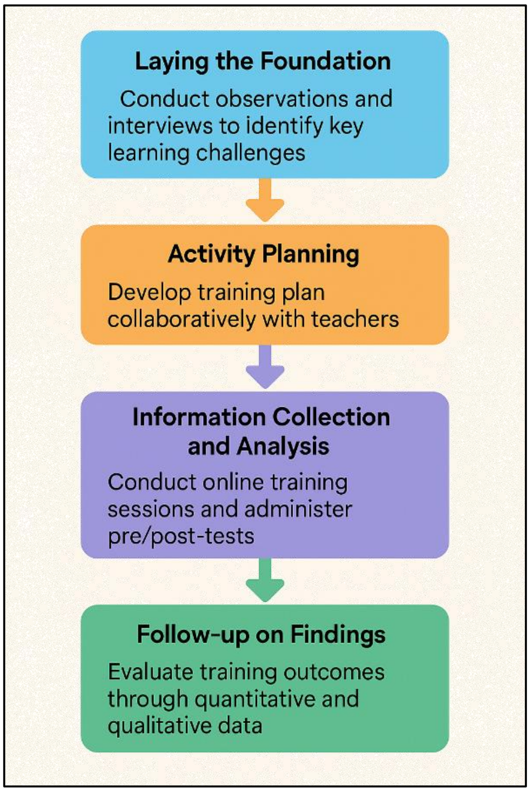

Figure 1. CBPR Framework for DELIVER training

The CBPR implementation began with initial observations followed by exploratory small-group interviews involving 12 physics and science teachers from different educational levels. These interviews were conducted as focus group discussions (FGDs) to elicit shared experiences, perceived challenges, and instructional practices related to the remediation of student misconceptions in learning. These findings formed the basis for designing contextual and relevant training materials. Together with the teachers, the implementation team developed a training plan focused on three main aspects: (1) the concept of deep learning, (2) identifying and addressing student misconceptions, and (3) developing refutation texts. The training was conducted online through synchronous (Zoom) and asynchronous (WhatsApp) sessions, conducted from June 21 to

June 27, 2025. The material was delivered through presentations, discussions, and exercises in developing refutation texts. A pre-test was administered to 237 physics teachers from various regions in Indonesia as part of the initial engagement. Due to voluntary participation, scheduling constraints, and incomplete post-training responses, only 87 teachers completed the post-test, and 69 participants with complete pre- and post-test data were included in the effectiveness analysis.

To evaluate training outcomes, both quantitative and qualitative data were collected. The pre-test and post-test instruments comprised seven multiple-choice questions and three short essay items, categorized into three domains as shown in Table 1, and were used to evaluate teachers' understanding of misconception remediation and the effectiveness of the DELIVER-based training intervention. Additionally, a post-training reflective survey was used to evaluate participants' perceptions of the material's clarity, relevance, and readiness to adapt the DELIVER strategy in the classroom. The survey also included five open-ended questions to elicit deeper reflection.

Table 1. Pre-test and Post-test Question Categories

Concept Category	Question Number
Deep Learning	1, 2, 6
Student' Misconceptions	3, 8, 9, 10
Refutation Texts	4, 5, 7

Descriptive statistical analysis included mean scores, standard deviations, percentage of correct responses, and normalized gain. Meanwhile, qualitative data from descriptive and reflective responses were analyzed thematically to identify transformations in teachers' thinking in designing misconception-based learning.

RESULTS AND DISCUSSION

This training activity was held as part of a community service program using a Community-Based Participatory Research (CBPR). This approach positions teachers as active partners in the process of identifying problems, planning solutions, implementing training, and reflecting on results. All stages of training follow the CBPR framework, which consists of: (1) Laying the Foundation, (2) Activity Planning, (3) Information Collection and Analysis, and (4) Follow-up on Findings. In this section, the results and discussion are presented according to these four stages, supplemented by quantitative and reflective analysis of the effectiveness of training based on the DELIVER (Deep Learning-Integrated Verbal Refutation) approach.

Laying the Foundation

The initial phase of the program centered on identifying the specific needs and pedagogical challenges faced by physics and science teachers through exploratory interviews conducted across various educational levels. These interviews revealed a consistent pattern: the majority of teachers were unfamiliar with the core components of the DELIVER approach, including the concepts of deep learning and the use of refutation texts. Misconceptions, while commonly encountered in classroom settings, were rarely addressed explicitly, and most teachers acknowledged the absence of systematic strategies to diagnose and remediate them. This diagnostic phase highlighted a critical gap in both conceptual knowledge and pedagogical tools, suggesting a widespread need for targeted professional development that moves beyond procedural teaching methods.

In addition to limited exposure to misconception-based strategies, many teachers expressed challenges in engaging with more advanced aspects of pedagogical literacy. Specifically, reflective instructional design, conceptual scaffolding, and evidence-based argumentation were areas where confidence and competence were lacking. These limitations underscore the importance of introducing the DELIVER approach, which integrates deep learning principles with the structured use of refutation texts to cultivate students' conceptual understanding. By bridging foundational content with reflective practice, DELIVER offers a pedagogically sound and contextually relevant solution, equipping teachers not only with strategies to confront misconceptions but also with the critical thinking framework necessary to foster meaningful learning in physics classrooms.

Activity Planning

Based on the initial identification results, the implementation team designed a comprehensive and phased training, focusing on three main pillars: (1) Deep Learning, (2) Understanding Misconceptions in Physics, and (3) Refutation Texts. The deep learning component introduced participants to a framework centered on meaningful, mindful, and joyful learning. Unlike surface learning, which focuses on memorization and short-term outcomes, deep learning emphasizes cognitive engagement, emotional relevance, and application of knowledge to real-world contexts. It promotes students' ability to integrate prior knowledge, reflect critically, and develop 21st-century competencies such as collaboration, communication, creativity, and character.

Building on this foundation, the training addressed the identification and understanding of misconceptions in physics as a critical pedagogical concern. Misconceptions are entrenched alternative conceptions that resist change and often stem from intuitive reasoning or prior experiences. In physics education, such misconceptions (e.g., "heavier objects fall faster") obstruct conceptual coherence and hinder higher-order thinking. Teachers were trained to identify these misconceptions diagnostically and to view them as essential entry points for learning, rather than as mere errors.

To support the correction of these misconceptions, the DELIVER training introduced refutation texts as a structured and evidence-based strategy for conceptual change. These texts follow a structured format: stating a common misconception, explicitly refuting it, and then presenting the correct scientific explanation. This format is designed to provoke cognitive conflict, an essential trigger for reevaluating prior beliefs, and to scaffold the construction of more coherent scientific understanding. By engaging in the development of refutation texts, teachers were not only exposed to a practical classroom tool but also challenged to reflect on their own explanations and assumptions, thus reinforcing the integration of all three training pillars into a cohesive instructional approach. Figure 2 presents a sample of training materials used during the DELIVER sessions, particularly the conceptual structure of the deep learning framework and structures of refutation texts. These resources were designed to guide teachers in constructing their own instructional texts that explicitly address common misconceptions.

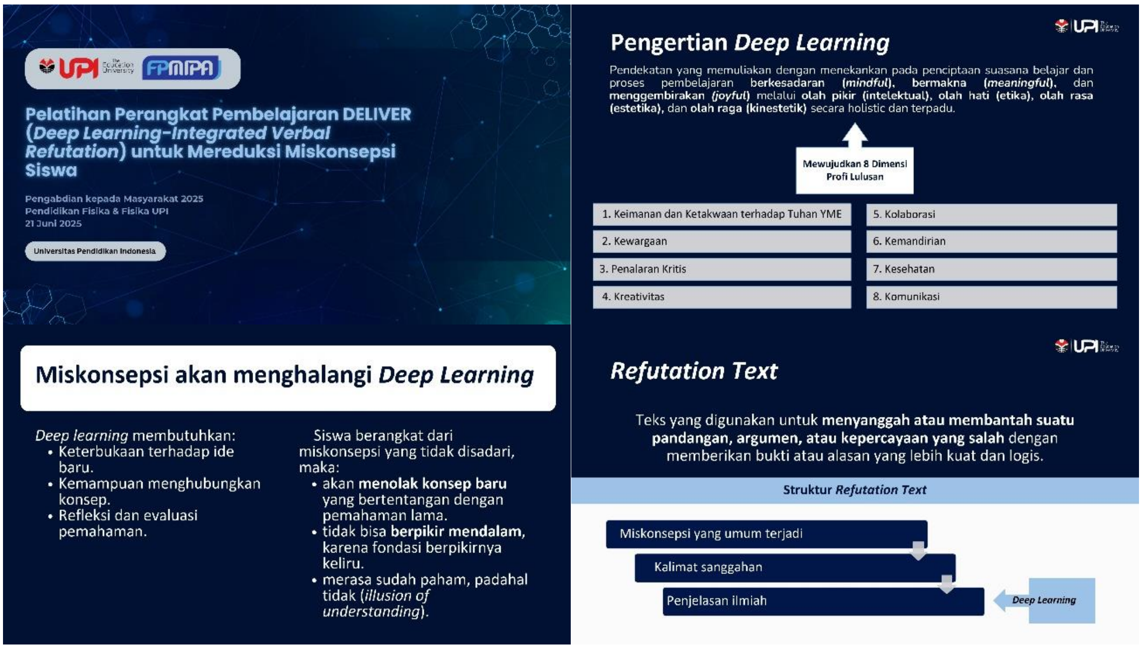

Figure 2. Materials for DELIVER training

The effectiveness of the training was evaluated using pre-test and post-test instruments consisting of seven multiple-choice questions and three short essay questions, each of which was developed to map participants' understanding of the three concept categories. The evaluation process was carried out online and anonymously to maintain the objectivity of the results. Figure 3 shows an example of the evaluation instruments used before and after the training.

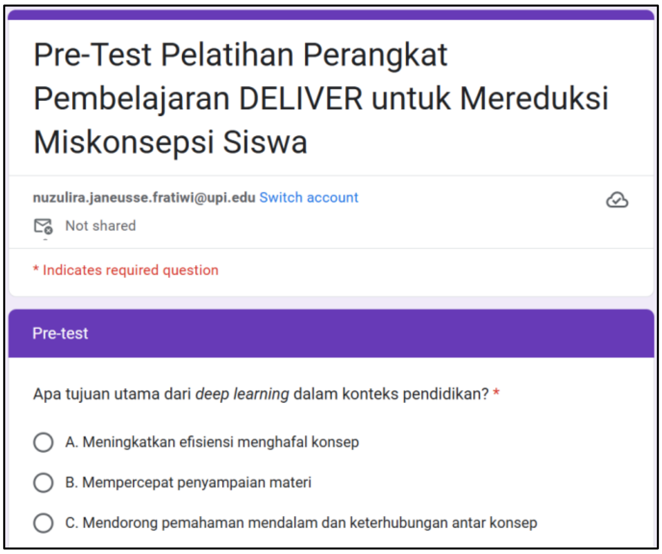

Figure 3. Example of evaluation questions for DELIVER training

Information Collection and Analysis

The training was conducted online through a combination of synchronous (Zoom) and asynchronous (WhatsApp) sessions, held from June 21 to June 27, 2025. The program commenced with a 90-minute live Zoom session on June 21, consisting of 60 minutes of structured material presentation, including the first 10 minutes allocated for a pre-test, and 30 minutes of interactive discussion. During this session, participants were introduced to the core principles of the DELIVER approach, which integrates deep learning approach with the use of refutation texts to address student misconceptions in physics. Facilitators provided curated examples of refutation texts and a standardized format template that embodied deep learning characteristics, encouraging mindful engagement, meaningful understanding, and joyful learning experiences. This session also allowed teachers to ask questions, clarify concepts, and reflect on their current classroom practices in light of the new framework. Figure 4 presents a screenshot from the synchronous session, capturing how the training materials on deep learning and refutation texts were delivered to participants.

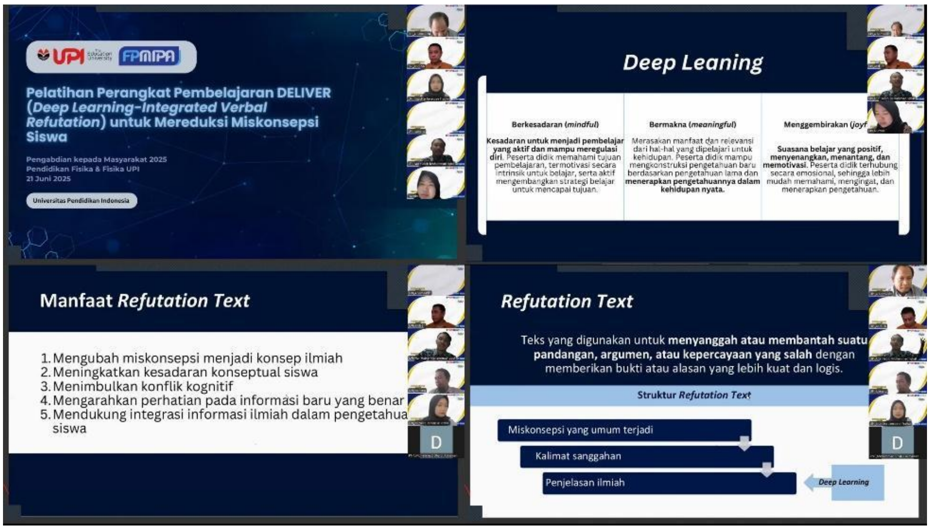

Figure 4. Online DELIVER training documentation displays material on deep learning and the structure of refutation texts

Following the synchronous session, participants continued their learning through asynchronous engagement on a dedicated WhatsApp group. This platform enabled sustained communication, peer collaboration, and formative feedback throughout the week. Participants were given a task to create their own DELIVER, applying the format introduced during the Zoom session. They submitted their assignments via Google Form alongside the post-test, allowing for both cognitive and reflective aspects of their learning to be assessed. Figure 5 shows a sample view of the DELIVER assignment shared with participants, including the format and guidance for developing refutation texts based on identified student misconceptions.

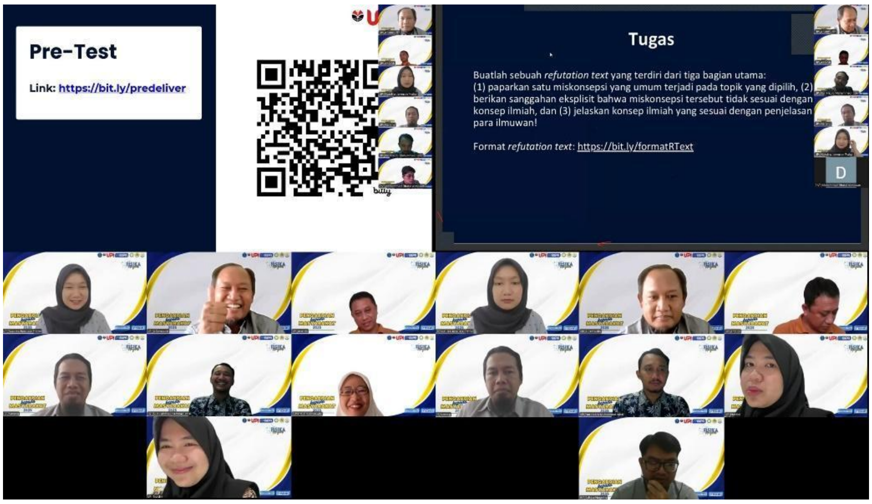

Figure 5. Screenshot of the DELIVER assignment given to participants as part of the training

Pre-test and post-test results showed a significant increase in participant understanding. The average number of errors in the pretest was 0.86 out of 7 questions, decreasing to 0.07 in the post-test. Table 2 presents a breakdown of average correct responses across three core concept categories: Deep Learning, Misconceptions in Physics, and Refutation Texts.

Table 2. Average Percentage of Correct Answers Based on Concept Category

Concept Category	Question No	Pre-test (%)	Post-test (%)
Deep Learning	1, 2, 6	95.08	98.64
Misconceptions in Physics	3	92.83	97.96
Refutational Text	4, 5, 7	78.90	96.60

Table 2 shows that participants' understanding of the refutational texts concept experienced the greatest increase, from 78.90% to 96.60%. This substantial gain suggests that the concept of refutational texts was relatively unfamiliar to most participants prior to the training and that the intervention had a significant impact on their conceptual development. The introduction of this strategy not only filled a gap in pedagogical content knowledge but also challenged teachers to adopt a more structured and research-informed method for addressing student misconceptions. This finding aligns with Susilowati et al. (2025), who highlighted that refutation texts are underutilized in Indonesian classrooms despite their effectiveness in creating cognitive conflict and promoting conceptual change. The structured nature of refutation texts has been widely supported in science education literature as an effective tool for confronting deeply held student misunderstandings (Danielson et al., 2025; Prinz et al., 2021; Samsudin et al., 2021; Taylor & Kowalski, 2023; Zengilowski et al., 2021). Distinct from these prior studies, the DELIVER program extends refutation text research by implementing it within a large-scale community service initiative using a Community-Based Participatory Research (CBPR) framework, emphasizing teacher empowerment and collaborative reflection rather than controlled classroom experimentation.

Conversely, the already high pre-test scores in the deep learning and misconceptions categories (95.08% and 92.83%, respectively) suggest that many participants had some prior exposure to these concepts. However, the post-test results (98.64% for deep learning and 97.96% for misconceptions) still demonstrated measurable improvement, indicating that the training reinforced and clarified participants' understanding. This outcome supports the assertion by Ehrenfeld (2022) that professional development programs, when framed around reflective and contextualized learning, can deepen teachers' conceptual frameworks, even in areas where prior familiarity exists. Rather than serving merely as a review, the DELIVER training encouraged participants to connect their knowledge of deep learning and student misconceptions with practical strategies for classroom implementation. This reinforces the idea that conceptual change is not only necessary for students, but also an ongoing process for teachers in refining their instructional practices.

Further confirmation of the training's effectiveness is shown in Figure 6, which illustrates the normalized gain values across all categories.

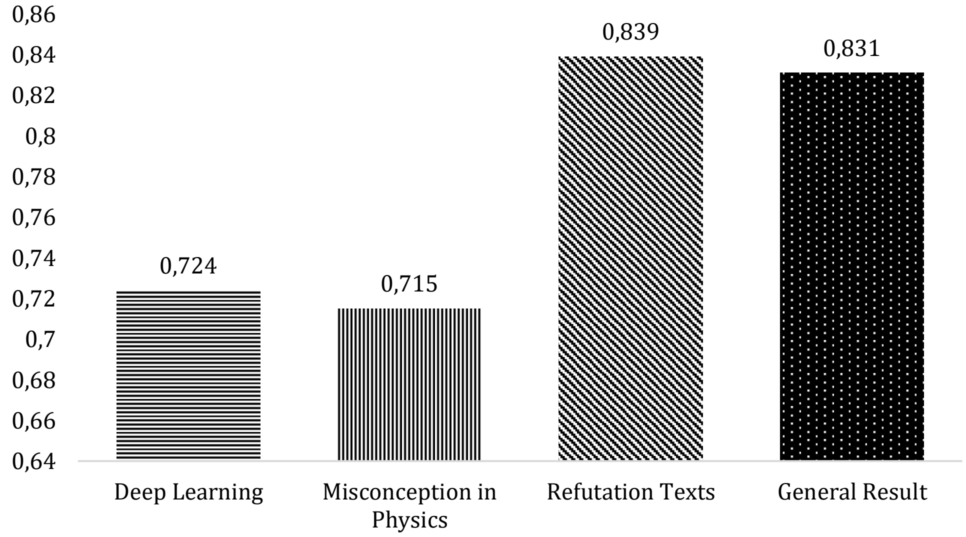

Figure 6. Bar chart showing the normalized gain values for each concept category and overall

Figure 6 shows that all categories fall within the normalized gain range of >0.7, which is considered high improvement according to Hake's classification. This confirms that the training was effective in improving teachers' understanding of refutation texts and strengthening their ability to design and implement misconception remediation strategies grounded in deep learning principles. The highest gain was recorded in the refutation texts category, reinforcing the conclusion that this area benefited most from the training. This outcome demonstrates the capacity of the DELIVER approach to equip teachers with novel, research-informed tools that had not previously been part of their instructional repertoire.

Complementing these findings, descriptive statistics in Table 3 show an increase in average scores from 6.15 to 6.84 and a decrease in standard deviation from 0.98 to 0.42.

Table 3. Descriptive Statistics of Participants' Pretest and Posttest Scores

Test Types	Average Score	Standard Deviation	Maximum Score
Pre-test	6.15	0.98	7
Post-test	6.84	0.42	7

The narrowing of score variation indicates that the training contributed to equity of understanding, helping teachers with initially lower scores catch up with their peers. According to Haxhiu (2023), this kind of narrowing gap is a key indicator of effective instructional intervention in teacher development programs. The overall normalized gain of 0.831 provides further evidence that the DELIVER training facilitated robust learning outcomes.

Then, qualitative analysis of the descriptive questions showed that participants were able to compose more logical, systematic, and contextual refutation texts after the training. Table 4 presents selected examples that compare participant responses before and after the training. These examples highlight conceptual progression in addressing common physics misconceptions.

Table 4. Example of comparison of participant's refutation answers before and after training

Misconceptions Addressed	Refuted (Pre-test)	Refute (Post-test)
Force always causes objects to move	Style makes things definitely move.	Not all forces cause motion. For example, friction can keep an object stationary.
Mass and weight are the same	Mass and weight mean the same thing, the units can also be kg.	Mass is the amount of matter, weight is the force of gravity. Weight depends on gravity.
Pressure depends on surface area	The pressure is greater if the surface area is large.	Pressure is inversely proportional to area: the smaller the area, the greater the pressure.
Heat is temperature	If the temperature is high, the heat must be large.	Heat is thermal energy in transfer. Temperature indicates the degree of heat. They are not the same.
Force only works if there is motion	Force acts only when an object is moving.	An object can be still but there is a force, for example normal force and static friction force.

Table 4 demonstrates a shift in participants' thinking, from simply stating concepts to constructing logical, data-based, and contextual rebuttals. For example, on the topic of "mass and weight," participants who previously equated the two terms can now explain the conceptual differences and their relationship to gravity. Such transformation aligns with the conceptual change model proposed by Ugwuanyi et al. (2023), which emphasizes the importance of creating cognitive conflict and supporting learners to reconstruct more accurate mental models. The structured format of refutation texts served as a catalyst for this shift. Additionally, Nadelson et al. (2018) highlight that effective conceptual change occurs when instruction is contextual, emotionally engaging, and encourages learners to reflect critically on their prior knowledge. The DELIVER approach, which integrates deep learning approach with refutation texts, thus not only improved teachers' content knowledge but also enhanced their pedagogical reasoning and ability to foster conceptual clarity in their classrooms.

Follow-up on Findings

A post-training survey completed concurrently with the post-test showed that the training had a positive impact on participants' perceptions. Most teachers stated that the training broadened their knowledge and felt prepared to implement the DELIVER approach in their teaching. Table 5 summarizes participants' responses to DELIVER training.

Table 5. Participant Responses to DELIVER Training (n = 51)

Statement	Number of "Yes"	Percentage of "Yes"
Did this training broaden your horizons?	48	94.12%
Are you ready to apply these strategies in your learning?	42	82.35%

The data in Table 5 shows that almost all participants felt the training broadened their knowledge (94.12%), and most felt ready to implement the DELIVER strategy (82.35%). These high percentages reinforce the participants' acceptance of the training. However, there is room for improvement in implementation readiness, which could be addressed through a community of practice or further mentoring.

Furthermore, participants' reflective responses demonstrated a deeper understanding of the role of misconceptions in learning and the importance of the DELIVER approach. Several participants reported that the training made them more aware of the need to explicitly identify and challenge misconceptions. For example, one participant wrote:

"*I learned that misconceptions must be addressed directly with the right strategies, not just re-explaining them*." (Participant 12)

Another participant stated that:

"*DELIVER made me rethink the way I teach. I rarely check students' initial understanding*." (Participant 35)

Meanwhile, the strategic aspects of refutation texts also receive attention:

"*The reference text is very helpful in explaining physics concepts that students often misunderstand, I want to try making my own version*." (Participant 27)

These findings, as reflected in the participants' statements above, demonstrate that the training not only improved teachers' cognitive understanding of misconception remediation but also fostered their professional awareness of their role as facilitators of students' conceptual change. However, challenges remain in developing effective and context-sensitive refutation sentences, indicating the need for sustained support beyond the initial training. Accordingly, follow-up initiatives such as mentoring programs and teacher practice communities are recommended to support the full implementation of the DELIVER strategy in classroom settings. Through the CBPR-based approach, teachers were actively engaged and encouraged to reconceptualize their pedagogical perspectives on misconceptions and deep learning, strengthening their role as agents of change in creating more reflective and meaningful physics learning. Taken together, these findings indicate that teachers' capacity to remediate student misconceptions through the DELIVER approach has been substantially enhanced.

LIMITATION

This community service activity, while demonstrating significant outcomes in empowering teachers through the DELIVER approach, has several limitations. First, the sample of participants analyzed in this study are 69 teachers out of 237 initially engaged, may not fully represent the broader population of physics teachers in Indonesia, particularly those from underserved or remote regions who may face different contextual challenges. The voluntary nature of participation also introduces potential self-selection bias, wherein those more motivated or experienced may have been more likely to complete both the pre- and post-tests.

Second, the training was conducted entirely online and within a short duration of one week. Although the combination of synchronous and asynchronous learning modes provided flexibility, the limited timeframe may have constrained deeper exploration, individual mentoring, or the opportunity to observe changes in classroom implementation. Third, this study focused primarily on short-term conceptual understanding and self-reported readiness, without longitudinal data to evaluate how the DELIVER strategy is actually applied and sustained in real classroom settings over time.

CONCLUSION

The implementation of the DELIVER approach through a Community-Based Participatory Research (CBPR) framework has proven effective in empowering physics teachers to address student misconceptions through the combined use of deep learning approach and refutation texts. By positioning teachers as active partners in identifying learning challenges and co-developing solutions, the program successfully bridged theoretical foundations with practical classroom applications. The deep learning approach encouraged cognitive engagement, reflection, and meaningful learning, while the refutation texts provided a concrete strategy to provoke cognitive conflict and correct entrenched misconceptions. Quantitative results, including high normalized gains and improved post-test scores, reflect significant cognitive growth among participants. Additionally, qualitative findings indicate a shift toward higher-order thinking, as evidenced by teachers' enhanced ability to construct logical, contextual refutations of misconceptions. These outcomes underscore the potential of the DELIVER approach to strengthen pedagogical competence and promote misconception-focused instruction in science education.

To ensure the sustainability and scalability of this initiative, several follow-up efforts are recommended. First, the establishment of professional learning communities or teacher mentoring programs could support continued development and classroom implementation of DELIVER strategies. Second, future iterations of the training should consider extending the duration or integrating offline components to allow deeper exploration and practice of misconception-based teaching. Lastly, longitudinal research is needed to evaluate the long-term impact of this training on instructional practices and student learning outcomes, as well as to explore the adaptation of the DELIVER model across other subject areas and educational contexts.

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