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Improving Math and Science Teachers' Understanding and Practical Skills of Case-Based Instruction: An Intensive Training Program in Bandar Lampung, Indonesia

Sunyono, Andrian Saputra*, Lisa Tania, & Annisa Meristin

Department of Chemical Education, Universitas Lampung, Indonesia

Abstract: This program was designed to bolster high school teachers' expertise in applying the case method to math and science instruction. Over six months, 19 teachers from Lampung Province participated in a structured series of lectures, workshops, and interactive sessions. The pretest and posttest evaluations highlighted significant gains in both conceptual understanding and the ability to develop case-based teaching materials. Participants were also trained to design student worksheets with digital tools like Canva, integrating scientific and socio-scientific scenarios into their lessons. By doing so, the program nurtured critical thinking, problem-solving, and environmental awareness among educators and their students. By equipping teachers with effective strategies for embedding real-world cases into their teaching, the initiative has taken a meaningful step toward advancing innovative practices in chemistry education and other scientific disciplines. To amplify its impact, expanding the program to additional regions and incorporating more classroom simulations is recommended. Such steps would further refine teachers' skills and boost student engagement with complex scientific topics. Emphasizing creativity, critical thinking, and real-world connections, this initiative represents a significant stride in enhancing high school science education.

Keywords: case-based instruction, high school teachers, socioscientific issues.

▪ INTRODUCTION

The realm of science education is constantly advancing, embracing innovative teaching techniques that nurture critical thinking, problem-solving abilities, and active student engagement. One such approach gaining prominence is the case-based method, a dynamic instructional strategy especially impactful in science classrooms. This method engages students with real-world scenarios or cases, requiring them to apply scientific concepts, think analytically, and collaborate to solve problems (Herreid, 2011). By situating learning within real-life contexts, the case-based method effectively connects theoretical understanding with practical application, enhancing both comprehension and retention of scientific principles (Yadav et al., 2007).

Studies consistently highlight the effectiveness of the case-based method in improving educational outcomes in science. By actively involving students in the learning process, this approach fosters inquiry and cultivates essential skills like teamwork, communication, and decision-making (Bonney, 2015; Herreid, 1994). Unlike traditional lecture-based teaching, which often emphasizes rote memorization, the case-based method promotes student-centered learning (Hmelo-Silver, 2004). This aligns closely with constructivist theories advocating for learning through active exploration and interaction with meaningful content (Prince & Felder, 2006; Vygotsky, 1978).

Research also indicates that the case-based method enhances students' problem-solving abilities and critical thinking, particularly in science and medical education (Hmelo-Silver & Barrows, 2006; Yadav et al., 2007). Furthermore, the use of real-life

Andrian Saputra
Email: andriansaputra@fkip.unila.ac.id

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scenarios in teaching improves student engagement and contextual understanding of complex concepts (Herreid & Schiller, 2013; Michael, 2006). The effectiveness of this method is underscored by its ability to make learning more relevant and applicable to real-world contexts (Lynch & Wolcott, 2001).

However, despite its many advantages, the adoption of the case-based method in science classrooms remains limited. This is especially true in regions where educators lack the necessary training and resources (Herreid & Schiller, 2013; Yadav et al., 2014). For example, high school chemistry teachers often struggle to integrate case-based scenarios into their teaching due to inadequate exposure to the method and a lack of pedagogical support (Allen & Tanner, 2003; Herreid, 2007). This highlights an urgent need for professional development programs designed to equip teachers with the skills and knowledge necessary to implement this approach effectively (Herreid & Schiller, 2013; Yadav et al., 2007).

Professional development initiatives are instrumental in improving education by enhancing teachers' understanding of innovative teaching practices. By engaging in well-structured training programs, educators can deepen their grasp of the theoretical principles underlying the case-based method while acquiring practical strategies for its implementation (Lundeberg et al., 2006). These programs empower teachers to create engaging and effective lesson plans while encouraging reflective teaching practices that support continuous professional growth.

In Bandar Lampung, incorporating case-based methods into high school chemistry education is particularly pertinent. Chemistry often requires students to bridge abstract concepts with practical applications. Through case-based learning, educators can present topics in a way that resonates with students, making the material both intellectually stimulating and relevant to real-world contexts (Reis et al., 2018). Furthermore, integrating socio-scientific issues into case-based lessons can foster environmental awareness and critical thinking, equipping students to tackle complex challenges within their communities (Zeidler et al., 2005).

This study examines a training program aimed at empowering high school chemistry teachers in Bandar Lampung with the expertise to implement the case-based method effectively. The program specifically addresses the challenges teachers face in designing and delivering case-based lessons, emphasizing the integration of the Nature of Science (NoS) and Environmental Awareness. By offering a comprehensive framework for professional development, the initiative seeks to enhance the quality of science education and promote a culture of innovative teaching practices. This paper outlines the objectives, methodology, and outcomes of the program, highlighting its broader implications for the adoption of case-based methods in science education.

▪ METHOD

Participants

This training program was specifically designed for high school math and science teachers in Lampung Province, with a focus on those teaching grades X and XI. To optimize the program's effectiveness in advancing knowledge and skill in innovative, interactive, and participatory teaching methods, the number of participants was capped at 19. Keeping the group small also minimized any disruptions to the participants' regular teaching schedules, as the sessions were held on Fridays and Saturdays. This schedule ensured that teachers could give their full attention to the training without compromising their classroom responsibilities.

Training Procedures

The training program was carried out in four distinct phases: Lectures: The program opened with lectures led by university faculty, focusing on core topics such as case-based learning, and socioscientific issues. These sessions provided foundational insights into the integration of case-based methods into chemistry lessons. Practical examples of innovative, interactive, and participatory teaching strategies were also shared to inspire participants in applying these techniques. Workshops and Training: Following the lecture sessions, participants took part in collaborative workshops. They received training on how to develop lesson plans and student worksheets using the case method. The workshops emphasized strategies to promote case-based learning among students. Through guided scenario-based activities, teachers experienced simulated case-based learnings. Practice: In this phase, teachers implemented their learning by crafting case-based lesson plans under the supervision of facilitators and the community service team. This hands-on approach enabled participants to develop scenarios that intertwined chemistry concepts with real-world socio-scientific and environmental issues. Presentations: The program concluded with participants presenting their lesson plans and worksheets to the group. They received feedback and constructive criticism from their peers and facilitators, which helped refine their work further. The program was a collaborative effort involving several institutions. Universitas Lampung, through LPPM Unila, provided funding and logistical support.

Evaluation

The program's success was assessed through a combination of pretests, posttests, observations, and participant feedback. Pretests and Posttests: A pretest conducted at the outset gauged participants' initial knowledge of case-based learning and their skill in creating related lesson plans. A posttest at the end evaluated improvements in these areas, with results analyzed to measure learning gains and overall achievement. Observation: Observations were carried out by students designated as observers. Using observation sheets designed by the program team, they recorded participants' engagement and activity during the sessions. This data offered valuable insights into how effectively participants adapted to the case-based learning methods. Questionnaires: Participants' feedback was collected via structured and open-ended questionnaires developed by the program team. These responses provided an overview of their satisfaction with the program and offered suggestions for improvement. The collected data from tests, observations, and questionnaires was meticulously organized and analyzed. This comprehensive evaluation highlighted significant advancements in participants' skills and satisfaction, confirming the training program effectively met its objectives.

▪ RESULT AND DISCUSSION

Assessing Initial Understanding

The program began with a pretest to assess participants' baseline knowledge of case method-based learning. The pretest included questions designed to evaluate their understanding of what case method-based learning is, the steps required for its implementation, the types of case methods based on how teachers present cases in the classroom, the differences between case method-based learning, problem-based learning, and context-based learning, and their ability to provide an example of a case that can be used in case method-based learning for high school chemistry. The pretest results revealed that 16 participants (84.21%) scored below 60, with scores ranging from 5 to 50, while the remaining 3 participants (15.79%) scored above 60, with scores between 63 and 78. These results highlighted significant gaps in participants' understanding of the conceptual framework of case method-based learning, the steps required for effective implementation in the classroom, and their ability to create relevant chemistry cases aligned with high school curricula. Specific challenges identified included difficulties in differentiating between case-based learning, problem-based learning, and context-based learning; limited understanding of the types of case methods based on classroom delivery strategies; and an inability to create chemistry-related cases, with several participants either providing incorrect examples or leaving the question unanswered. These findings align with prior research emphasizing the need for structured training in innovative teaching methods to bridge gaps in teacher preparedness (Herreid, 2011; Prince & Felder, 2006).

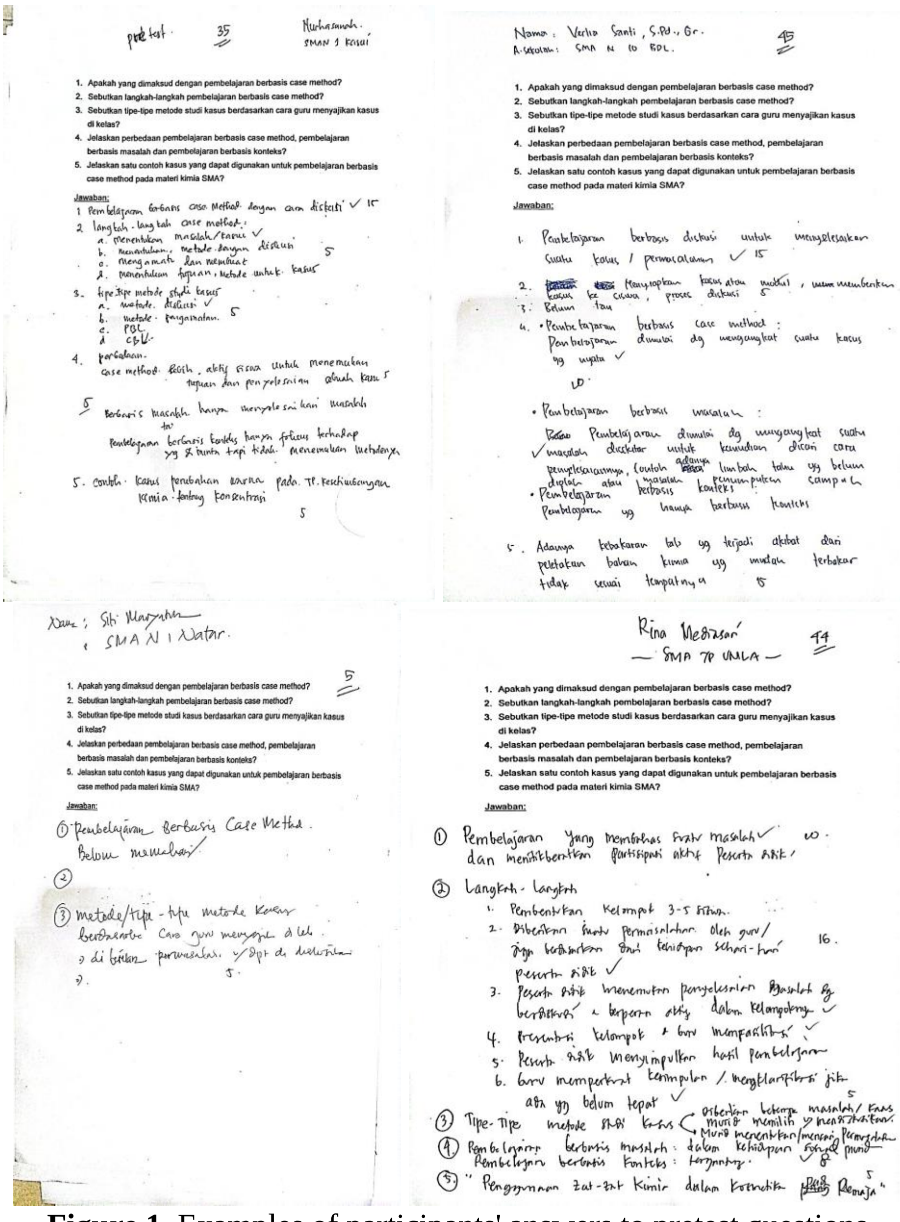

Figure 1. Examples of participants' answers to pretest questions

Training Sessions

The first session was delivered by instructor 1, who provided a theoretical and practical overview of using real-life cases in differentiated learning. Instructor 1 explained the role of case studies in fostering critical thinking, problem-solving, and collaborative learning, citing studies by Bonney (2015) and Yadav et al. (2007). He discussed practical examples of cases from daily life, such as the chemistry behind pollution, food adulteration, and drug interactions, and tied these examples to socio-scientific issues to make the learning process more engaging and relevant. The speaker also demonstrated how cases could be adapted to cater to students with varying levels of ability and interest, emphasizing the importance of scaffolding. The second session, led by Instructor 2, focused on the specifics of case method-based learning in chemistry. He provided theoretical and practical guidance on creating structured, open-ended, and guided inquiry cases, introduced a step-by-step framework for case-based learning from case selection to classroom discussion and reflection, and detailed comparisons between case-based learning, problem-based learning, and context-based learning. He also highlighted credible resources such as the National Science Teaching Association (NSTA) website, which provides socio-scientific cases suitable for high school chemistry teaching (https://www.nsta.org/case-studies). The final session, conducted by Instructor 3, introduced participants to the RADEC (Read, Answer, Discuss, Explain, Create) approach. Participants learned to design case-based student worksheets using Canva. Assisted by university students, participants collaborated in groups to create visually appealing and pedagogically sound worksheets. This session emphasized the role of digital tools in enhancing instructional design (van Merriënboer & Kirschner, 2018).

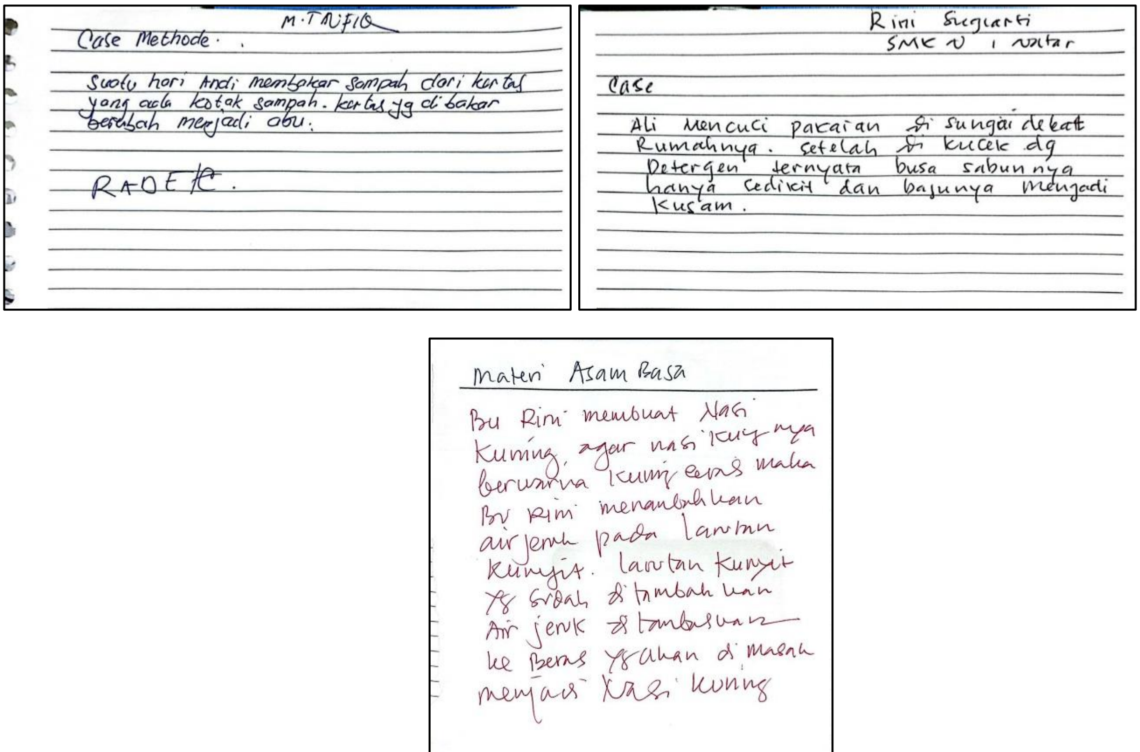

Figure 2. Example of cases generated by some participants

Posttest Analysis

After the training sessions, participants were tasked with creating and presenting their own cases. While most participants demonstrated significant improvement, some challenges remained, particularly in formulating higher-order questions. Examples of participants' cases are shown in Figure 4.2. A posttest was conducted to evaluate the effectiveness of the training. The results showed marked improvement, with all participants scoring above 60, ranging from 60 to 100. A comparison of pretest and posttest scores is presented in Figure 4.3, demonstrating the training's success in enhancing participants' understanding and skills.

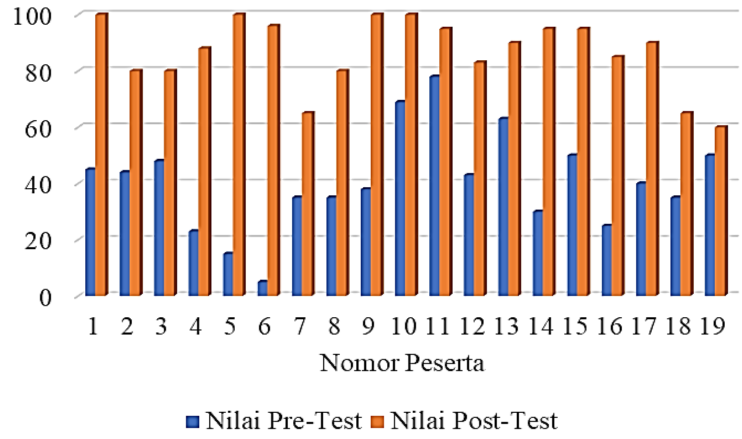

Figure 3. Comparison of pretest (blue) and posttest (orange) scores

The training program significantly improved participants' knowledge and skills in case method-based learning. Participants showed an increased ability to conceptualize and implement case-based learning strategies, as evidenced by the significant improvement in posttest scores and the quality of cases they developed during the program. Despite these achievements, several aspects warrant further attention to ensure sustained and effective implementation of the case method in chemistry education. One key recommendation is the provision of ongoing mentorship for teachers to address challenges that arise during the implementation phase. Mentorship programs could include classroom observations, feedback sessions, and professional learning communities where teachers can share experiences and refine their practices.

Another recommendation is the development of a centralized repository of chemistry-related cases tailored to the Indonesian high school curriculum. This repository should include a variety of cases that span different topics and difficulty levels, integrating real-world contexts and socio-scientific issues to foster student engagement. Collaborative efforts between universities, schools, and educational organizations could ensure the repository remains dynamic and relevant. Additionally, teachers should be encouraged to contribute to and utilize this repository, fostering a culture of collaboration and continuous improvement.

The integration of the case method with other innovative teaching strategies, such as flipped classrooms and blended learning, also holds significant potential. Combining these approaches can provide students with pre-class exposure to foundational concepts, allowing class time to be devoted to case discussions and higher-order thinking activities.

This integration can also leverage technology to enhance accessibility and interactivity, particularly in the context of remote or hybrid learning environments.

Finally, systematic research should be conducted to evaluate the long-term impact of the case method on student learning outcomes, including critical thinking, problem-solving, and scientific literacy. Such research can inform policy and practice, ensuring that the adoption of the case method aligns with broader educational goals. By addressing these recommendations, stakeholders can maximize the impact of the case method and contribute to the advancement of chemistry education in Indonesia.

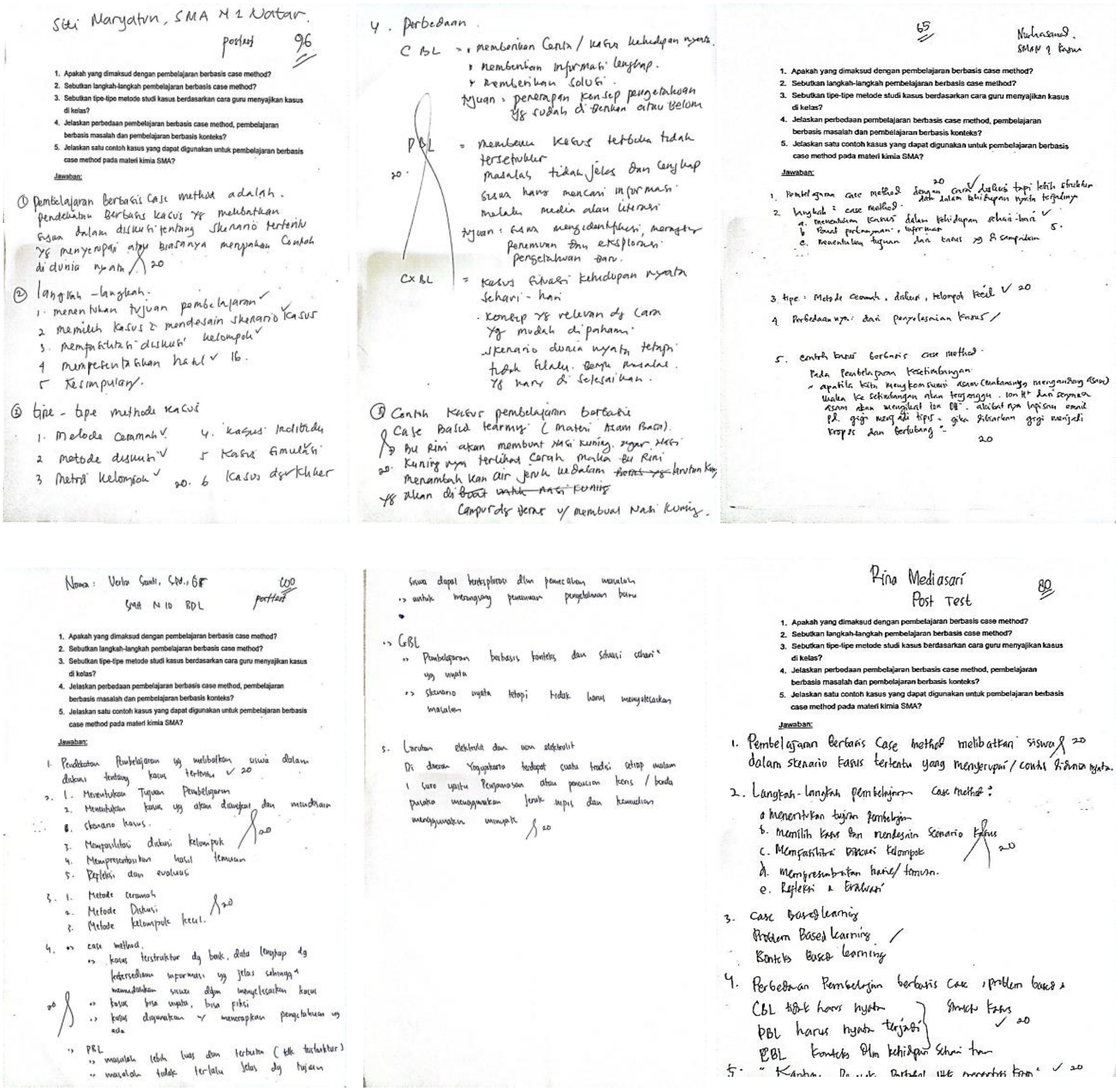

Figure 4. Examples of participants' answers in posttest

▪ CONCLUSION

This study highlights the effectiveness of the case-based method as a powerful teaching strategy for improving science education, with a particular focus on high school math and science learning. The findings from the training program reveal that teachers showed notable gains in understanding the principles of case-based learning and applying them in the classroom. Pretest and posttest evaluations demonstrated a significant improvement, with all participants achieving posttest scores above 60. These results suggest the training successfully addressed initial knowledge gaps, equipping educators with the skills to create case-based learning activities that incorporate both the socioscientific issues. Moreover, the collaborative, hands-on approach of the training deepened teachers' engagement, enabling them to develop innovative, interactive lesson plans and worksheets tailored to their classroom contexts. This study contributes to ongoing discussions about educational innovation, emphasizing the need to empower teachers with contemporary teaching methods that enhance science education while fostering critical thinking and problem-solving skills among students.

The implications of this research extend beyond the scope of the training itself. By equipping educators to implement the case-based approach, the study advocates for a broader shift toward student-centered, inquiry-driven pedagogy in science education. Such methods not only strengthen students' grasp of scientific concepts but also nurture their critical thinking, environmental consciousness, and ability to tackle real-world problems. However, the research acknowledges certain limitations. The program was conducted with a small sample size of 19 teachers, and the assessment primarily measured short-term knowledge gains. Future studies should investigate the longer-term effects of such training on teaching practices and student outcomes, including classroom implementation and performance metrics. Expanding the program to involve a more diverse group of educators and disciplines would also provide valuable insights into the broader applicability of case-based learning. Despite these limitations, this study offers a robust model for professional development initiatives aimed at fostering innovation in science education.

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