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STEM-PjBL-Based Science Instructional Design Training for Junior High School Science Teacher in Takalar Regency, Indonesia

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Abstract: Teachers play an essential role in translating the STEM approach into contextualized and meaningful learning experiences. However, implementing STEM in science education requires more than an understanding of its individual components; it also demands teachers' ability to integrate these components into problem- and project-based instructional designs. This community engagement program aimed to strengthen the competencies of junior high school science teachers in designing STEM-based learning through Project-Based Learning (PjBL). The program involved 46 junior high school science teachers in Takalar Regency, Indonesia. The implementation methods comprised conceptual reinforcement, model demonstrations, guided practice, instructional design development, and evaluation. The instructional design activities guided participants through identifying contextual problems, formulating driving questions, determining project outcomes, designing project activities, identifying PjBL stages, and mapping STEM components. Program outcomes were evaluated using pretests and posttests, as well as questionnaires assessing participants' perceptions, readiness, and responses to the program. Evaluation of the 32 participants with complete paired pretest and posttest data revealed an increase in the mean score from 81.70 to 87.05, representing a gain of 5.36 points. Of these participants, 15 demonstrated improved scores, 9 maintained the same scores, and 8 experienced a decrease. Participants' perceptions and readiness regarding STEM-PjBL-based learning achieved a mean score of 3.58 on a four-point scale, with 96.25% positive responses. Meanwhile, participants' responses to the program implementation reached a mean score of 3.66, with 100% positive responses. These findings indicate that the program yielded positive outcomes in strengthening teachers' understanding and readiness to design STEM-PjBL-based science learning. Further initiatives involving sustained mentoring and classroom implementation are necessary to enhance program sustainability and ensure that the knowledge and skills acquired can be effectively translated into actual teaching practices.

Keywords: Science teachers, STEM, Project-Based Learning, instructional design, teacher professional development.

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INTRODUCTION

The evolving demands of 21st-century education require teachers to design learning experiences that go beyond conceptual mastery and enable students to apply their knowledge to understand and address real-world problems. In science education, this demand is particularly relevant because scientific concepts are closely interconnected with technology, engineering, mathematics, and various issues encountered in everyday life. The Science, Technology, Engineering, and Mathematics (STEM) approach is one of the approaches that can be adopted to facilitate learning experiences that connect these disciplines within authentic contexts. The effectiveness of STEM implementation in improving students' science learning outcomes and 21st-century skills has been demonstrated through various empirical studies conducted across different regions (Wahono et al., 2020).

Implementing STEM in science education requires more than simply introducing its four components. Teachers need to understand how science, technology, engineering, and mathematics concepts can be interconnected through problems that encourage students to conduct investigations, design solutions, utilize technology, and apply mathematical concepts. However, teachers may encounter difficulties in establishing meaningful connections among STEM disciplines. Therefore, a conceptual framework and relevant learning experiences are needed to help teachers understand and establish these interdisciplinary connections (Kelley & Knowles, 2016).

Community engagement activities have also demonstrated the potential of STEM-based approaches to facilitate contextualized learning through practical experiences and problem-solving activities. For instance, Khoeriah et al. (2026) implemented STEM-based activities in disaster mitigation education, while Kelana et al. (2025) demonstrated the use of simple instructional tools to support science learning. These initiatives highlight the importance of connecting scientific concepts with practical activities and real-world contexts.

One pedagogical approach that aligns well with STEM education is Project-Based Learning (PjBL). PjBL provides students with opportunities to learn through problems or projects that result in specific artifacts or products. In science education, the key characteristics of PjBL include collaboration, technology integration, problem orientation, artifact development, scientific practices, presentation of findings, and reflection (Markula & Aksela, 2022). Accordingly, PjBL provides a pedagogical structure through which STEM integration can be implemented in more contextualized and problem-solving-oriented learning activities.

Nevertheless, implementing STEM-PjBL in science education requires adequate teacher readiness. Teachers need not only conceptual understanding but also practical experience in translating these concepts into instructional designs. Teacher professional development is one strategy that can be employed to strengthen such capacities. A systematic review of STEM teacher professional development programs found that these programs frequently incorporate approaches such as *learning by design*, *learning by doing*, reflective learning, and collaborative group work. These approaches enable teachers to engage actively in the learning process and connect theoretical knowledge with instructional practices (Huang et al., 2022).

Needs-based professional development is particularly important to ensure that training activities address teachers' actual instructional challenges. Widarti et al. (2024) emphasized the importance of identifying teachers' needs and difficulties as a foundation for designing relevant professional development programs. Similarly, Muthmainnah et al. (2025) demonstrated that workshops and mentoring activities can strengthen teachers' pedagogical content knowledge while supporting the development of instructional materials.

Surahman dan Wang (2023) also reported that workshops and training sessions are among the most commonly employed formats in STEM teacher professional development

programs. Their review of 44 articles revealed that constructivist approaches are widely adopted in STEM teacher professional development, particularly through activities that promote active engagement, collaboration, and knowledge construction based on experience. These findings suggest that teacher capacity-building programs should provide opportunities for participants not only to receive information but also to apply the knowledge acquired through practical activities.

The need for more contextualized professional development has also been highlighted in recent studies. Rehman et al., (2025) emphasized that STEM professional development programs should address interdisciplinary integration, curriculum innovation, technological competence, and context-specific regional needs. Their review also highlighted the importance of implementing more comprehensive program evaluations that extend beyond teachers' self-reported perceptions.

In response to these considerations, capacity-building initiatives are needed to help science teachers connect the principles of STEM and PjBL with the actual needs of science instruction. This community engagement program was conducted to support junior high school science teachers in Takalar Regency, Indonesia, through educational sessions and practical activities focused on STEM-PjBL-based instructional design. Rather than focusing solely on conceptual delivery, the program provided participants with opportunities to develop instructional designs based on contextual problems relevant to science learning.

Accordingly, this program aimed to strengthen junior high school science teachers' understanding and readiness to design STEM-PjBL-based learning while providing practical experience in developing instructional designs that integrate contextual problems, PjBL stages, and STEM components.

METHOD

The community engagement program was conducted in collaboration with 46 junior high school science teachers in Takalar Regency, Indonesia, who were members of the Science Subject Teachers' Working Group (*Musyawarah Guru Mata Pelajaran* or MGMP IPA).

The selection of science teachers as program partners was based on the need to strengthen their capacity to design learning activities that connect scientific concepts with contextual problems and promote project-based learning. The program was designed by taking into account the characteristics of teachers as adult learners. Therefore, the learning process involved not only the delivery of instructional materials but also opportunities for experience sharing, discussion, and hands-on instructional design activities.

The program was implemented through five interconnected stages: conceptual reinforcement, model presentation, guided practice, instructional design development, and evaluation. The implementation of these stages was informed by community-based teacher development practices that combine conceptual instruction, practical activities, collaborative learning, and evaluation. Similar approaches have been applied in teacher training programs through workshops, group assignments, instructional simulations, and guided development of learning products (Siregar et al., 2025; Supriyadi et al., 2023).

Stage 1. Conceptual Reinforcement

The initial stage focused on developing participants' understanding of the fundamental concepts of STEM and PjBL. The materials covered the characteristics of PjBL, the principles of STEM integration, contextual problems in science education, and the relationship between project activities and students' learning experiences.

At this stage, participants were not merely introduced to STEM terminology but were also encouraged to understand the function of each STEM component in the context of

problem-solving. This was important because STEM integration emphasizes the interconnectedness of different disciplines within authentic contexts rather than simply incorporating the four STEM components into instructional materials.

Stage 2. Model Presentation

Participants were introduced to examples of STEM-PjBL-based instructional designs to illustrate how contextual problems could be transformed into learning projects. These examples served as a bridge between conceptual understanding and practical application, providing participants with a concrete illustration of the relationships among contextual problems, driving questions, project outcomes, student activities, PjBL stages, and STEM integration.

Stage 3. Praktik Terbimbing

At this stage, participants began developing instructional designs through guided activities. They were encouraged to identify problems relevant to science learning and the everyday environments of their students.

Subsequently, participants developed the following components:

1. Contextual problems;
2. Driving questions;
3. Project products or outcomes;
4. Activities to be conducted throughout the project;
5. PjBL stages; and
6. Relevant STEM components.

Teachers' ability to formulate appropriate driving questions and design effective project frameworks plays a crucial role in determining the quality of conceptual understanding developed by students throughout the learning process (Widoretno et al., 2023). This process provided teachers with opportunities to directly apply the knowledge they had acquired (Figure 1). Such an approach is consistent with the characteristics of STEM professional development, which emphasizes learning by doing and learning by design as strategies for connecting teachers' knowledge with instructional practices (Huang et al., 2022).



Figure 1. Guided Practice in Developing STEM-PjBL-Based Lesson Plans

Stage 4. Instructional Design Development

Participants refined their instructional designs based on the outcomes of the guided practice activities. At this stage, as illustrated in Figures 2 and 3, participants were guided to consider the alignment among contextual problems, projects, learning activities, and STEM

components. This stage was not merely intended to produce administrative instructional documents but also to support teachers in developing learning experiences that enable students to apply scientific knowledge in more authentic contexts.



Figure 2. Participants engaging in collaborative discussions to develop instructional designs.

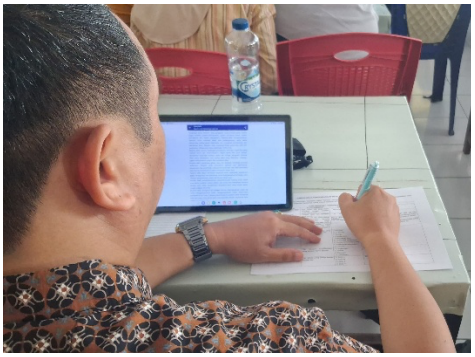


Figure 3. Participants completing the worksheet for formulating PjBL-STEM learning activities.

Stage 5. Evaluation

An evaluation was conducted to obtain an overview of participant' achievement following the program (Figure 4). The evaluation comprised:

1. pretest dan posttest to assess changes in participants' understanding;
2. questionnaires on participants' perception and readiness to implement STEM-PjBL-based learning
3. questionnaires assessing participants' responses to the program implementation;

The data were analyzed descriptively by calculating mean scores and percentages of positive responses. Pretest and posttest data were analyzed based on participants who had complete data from both measurement periods.



Figure 4. Participant completing the Pretest and Postest

RESULTS AND DISCUSSION

Implementation of STEM-PjBL Instructional Design Training

The program was conducted by positioning teachers as active participants in the learning process. The approach extended beyond delivering materials on STEM and PjBL concepts to include hands-on activities in developing instructional designs. The process began with an introduction to the fundamental concepts, followed by activities in which participants identified problems that could serve as contexts for science learning. These problems were subsequently developed into driving questions and projects that would enable students to produce specific products or solutions.

These activities constituted an essential component of the program, as STEM integration requires meaningful connections between concepts, contexts, and practices. Kelley dan Knowles (2016) explained that integrated STEM education can be situated within authentic contexts by connecting practices across different STEM domains.

Similar findings have been reported in community engagement programs focusing on teacher capacity development. Muthmainnah et al. (2025) demonstrated that workshop-based training combined with mentoring can support teachers in developing instructional materials and strengthening pedagogical content knowledge. Silaban et al. (2023) also highlighted the contribution of ICT-based training and mentoring in strengthening teachers' professional competencies. These findings reinforce the importance of providing teachers with opportunities to develop practical competencies through structured training activities rather than relying solely on theoretical explanations.

During the instructional design process, teachers were also guided to identify and map the Science, Technology, Engineering, and Mathematics components relevant to their proposed projects. This mapping activity helped teachers recognize that the four components do not necessarily function as separate elements but can complement one another in the process of problem-solving.

The instructional design activities also reflected the characteristics of PjBL in science education. Markula & Aksela (2022) found that science projects commonly incorporate several key characteristics, including collaboration, artifact development, technology integration, problem orientation, scientific practices, presentation, and reflection.

Therefore, the activities provided in this program were designed to foster practical instructional design experiences that teachers could subsequently adapt and implement in their respective teaching contexts.

Changes in Participants' Understanding

Participants' understanding was assessed through pretests and posttests. Of the 46 teachers who participated in the program, 32 had complete and matched pretest and posttest data.

Tabel 1. Comparison of Pretest dan Posttest Scores

Indicator	Pretest	Posttest
Number of participants	32	32
Mean	81,70	87,05
Standard deviation	16,32	18,27
Minimum score	42,86	14,29
Maximum score	100,00	100,00
Mean score difference		+5,36

Tabel 1 shows that the mean score increased from 81.70 to 87.05, representing an improvement of 5.36 points. This finding indicates a positive change in participants' understanding following their involvement in the educational activities. At the individual level,

15 out of 32 participants demonstrated improved scores, while 9 participants obtained unchanged scores and 8 experienced a decrease. This pattern suggests that the program's outcomes were not uniform across all participants.

The improvement in participants' understanding can also be viewed in relation to the importance of strengthening teachers' competencies in designing learning activities and assessments that promote 21st-century skills. Sarwi et al. (2023) highlighted the need to develop science assessment practices that are oriented toward 21st-century competencies. This perspective supports the importance of preparing teachers not only to understand STEM-PjBL concepts but also to translate them into instructional designs that promote students' scientific reasoning, problem-solving, and other essential competencies.

These findings are understandable given that participants had varying levels of prior experience and proficiency. In teacher professional development programs, changes in competencies can be influenced by various factors, including prior knowledge, teaching experience, school context, and the format and duration of the program. Rehman et al. (2025) also emphasize the importance of considering regional contexts and needs in STEM professional development.

The results indicate that an approach combining conceptual reinforcement with design practice provides teachers with the opportunity to transform the knowledge they have gained into instructional designs. However, changes in scores cannot be used as a basis for establishing a causal relationship regarding the program's effectiveness because the study did not include a control group. These results are more appropriately interpreted as indicators of participants' understanding gained during the program.

Discussion of Participants' Unders

Further analysis was conducted by examining the percentage of correct

Tabel 2. Percentage of Correct Responses for Each Test Item

Item	Pretest	Pretest	Posttest
1	81,25	93,75	+12,50
2	84,38	96,88	+12,50
3	71,88	90,63	+18,75
4	71,88	87,50	+16,53
10	93,75	96,88	+3,13
14	84,38	81,25	-3,13
15	84,38	62,50	-21,88

The greatest improvement was observed in Item 3, with an increase of 18.75 percentage points, followed by Item 4, with an increase of 15.63 percentage points. Improvements were also recorded in Items 1 and 2, each showing an increase of 12.50 percentage points. This pattern indicates that the program contributed to strengthening several aspects of participants' understanding of STEM-PjBL instructional design. However, the evaluation results also indicate that improvements were not consistent across all items. Item 15 showed a decrease of 21.88 percentage points, while Item 14 experienced a decline of 3.13 percentage points.

These findings are important for future program development because they demonstrate that improvements in one aspect of understanding do not necessarily indicate mastery of all STEM-PjBL components. In the context of community engagement, such evaluation results can serve as a basis for identifying areas that require further mentoring and support.

STEM integration itself can present a particular challenge for teachers. Kelley and Knowles (2016) explained that connecting STEM disciplines within authentic contexts is a complex process, and teachers may experience difficulties in establishing meaningful

interdisciplinary relationships. Therefore, mentoring that provides opportunities for teachers to practice, receive feedback, and continuously improve their instructional designs is essential.

Huang et al. (2022) also demonstrated that STEM professional development programs incorporating *learning by design*, *learning by doing*, reflection, and collaborative group work provide experiences that are closely connected to actual instructional practices. Accordingly, the evaluation findings support the view that this program should not be regarded as a one-time training activity but rather as an initial stage in an ongoing process of teacher competency development.

Teachers' Perception and Readiness

In addition to assessing learning outcomes, the program evaluated participants' perceptions and readiness to implement STEM-PjBL-based learning

Tabel 3. Participants' Perception and Readiness

Item	Mean Score	Positif Responses
6	3,68	96,77%
7	**3,69**	**100,00%**
8	3,58	93,55%
9	3,44	93,75%
10	3,53	96,88%
Rata-rata	**3,58**	**96,25%**

The overall mean score for participants' perceptions and readiness was 3.58 out of a maximum score of 4, with 96.25% positive responses. The highest score was recorded for Item 7, with a mean of 3.69, and all participants provided positive responses. This finding indicates that participants recognized the importance of using contextual problems in science learning.

This positive perception is consistent with the characteristics of integrated STEM education, which connects scientific concepts with authentic contexts. Kelley and Knowles (2016) emphasized the importance of authentic contexts in establishing connections among different STEM domains. Meanwhile, the lowest mean score was recorded for Item 9, at 3.44. Although this score still indicates a generally positive perception, it suggests that certain aspects related to teachers' ability to identify or map STEM components require further strengthening.

This finding is particularly relevant to teacher empowerment. Although participants may positively perceive the concept of STEM-PjBL, such acceptance needs to be accompanied by sufficient practical experience to enable teachers to translate these ideas into instructional designs. Therefore, subsequent activities could focus on instructional design mentoring, peer discussions, peer review, and design revision. These strategies are consistent with the characteristics of STEM professional development, which emphasize active engagement and the connection between knowledge and practice (Huang et al., 2022; Surahman & Wang, 2023).

Participants' Responses to Program Implementation

This evaluation also examined participants' responses to the implementation of the program.

Tabel 4. Participants' Responses to Program Impelentation

Item	Mean Score	Positif Responses
6	**3,75**	100,00%
7	**3,75**	100,00%
8	3,59	100,00%
9	3,56	100,00%
10	3,63	100,00%
Rata-rata	**3,66**	**100,00%**

The overall mean response score was 3.66 out of 4, with all responses falling within the positive category. These results indicate that participants demonstrated favorable acceptance of the program implementation. The high proportion of positive responses also suggests that combining conceptual explanations with instructional design practice was well received by teachers as a professional development activity.

These findings are consistent with Surahman and Wang (2023), who reported that workshops and training sessions are among the most commonly used formats in STEM teacher professional development. Their review also highlighted the importance of active, collaborative, and constructivist learning activities in professional development programs.

Nevertheless, positive responses were not considered the sole indicator of program success. Participants' responses primarily provided information regarding their acceptance of and experiences during the program. Further evaluation of instructional design implementation in schools is necessary to determine the sustainability of the program's impact.

Program Sustainability and Partner Empowerment

One of the essential characteristics of community engagement programs is the sustainability of their benefits beyond the completion of the activities. Therefore, program outcomes should not be assessed solely based on achievements during implementation but also in terms of the potential for partners to utilize the knowledge and skills acquired.

Through this program, teachers gained experience in developing instructional designs based on contextual problems. These designs can be further adapted to various science topics by considering the characteristics of the subject matter, school environments, available resources, and students' learning characteristics.

STEM teacher professional development ideally needs to be implemented as a continuous process. Rehman et al. (2025) emphasized the importance of the duration of professional development programs and approaches tailored to specific regional needs and contexts. Meanwhile, Huang et al. (2022) highlighted the importance of considering teachers' performance products and processes rather than relying solely on their perceptions of professional development activities.

Based on these findings, program sustainability can be pursued through three follow-up activities. First, instructional design mentoring, which involves providing feedback on the instructional designs developed by teachers. Second, limited classroom implementation, allowing teachers to test the feasibility of their designs in authentic teaching contexts. Third, reflection and professional experience sharing, through which implementation experiences can be used to improve subsequent instructional designs.

Therefore, the activities conducted in this program can serve as an initial step toward establishing more sustainable professional development practices within the science teachers' community in Takalar Regency.

CONCLUSION

The community engagement program focusing on STEM-PjBL-based science instructional design training yielded positive outcomes in strengthening the capacity of junior high school science teachers in Takalar Regency, Indonesia. The program was implemented through five stages: conceptual reinforcement, model presentation, guided practice, instructional design development, and evaluation. This approach provided teachers with opportunities to connect contextual problems with PjBL stages and identify the integration of STEM components within their instructional designs.

The evaluation results indicated changes in participants' learning outcomes, although improvements were not consistent across all assessed aspects. These findings suggest that the approach introduced through the program was well received by the partner teachers and considered relevant to supporting science education.

Nevertheless, the decline observed in several evaluation aspects indicates that strengthening teachers' competencies cannot be achieved through a single training session alone. Further initiatives should focus on mentoring, peer review, classroom implementation of instructional designs, reflection, and instructional material revision. Through this approach, community engagement activities are expected to extend beyond improvements in understanding during the training and develop into sustainable STEM-PjBL instructional practices in schools.

REFERENCES

Huang, B., Siu-Yung Jong, M., Tu, Y.-F., Hwang, G.-J., Chai, C. S., & Yi-Chao Jiang, M. (2022). Trends and exemplary practices of STEM teacher professional development programs in K-12 contexts: A systematic review of empirical studies. *Computers & Education*, *189*, 104577. https://doi.org/https://doi.org/10.1016/j.compedu.2022.104577

Kelana, A. H., Karubaba, M., Irawan, S., & Suryani, S. W. (2025). Pembuatan alat peraga sederhana IPAS pada materi listrik kelas V SD Al-Ihsan Yapis Kotaraja. *Samakta: Jurnal Pengabdian Kepada Masyarakat,* 2(1), 25–34. https://doi.org/10.61142/samakta.v2i1.191

Khoeriah, I. A., Putri, D. A. K., Dewanti, L., & Hadiwijaya, H. (2026). STEM-based fire disaster mitigation training to foster safety awareness among early childhood education students. *Samakta: Jurnal Pengabdian Kepada Masyarakat,* 3(1), 54–67. https://doi.org/10.61142/samakta.v3i1.333

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, *3*(1), 11. https://doi.org/10.1186/s40594-016-0046-z

Markula, A., & Aksela, M. (2022). The key characteristics of project-based learning: how teachers implement projects in K-12 science education. *Disciplinary and Interdisciplinary Science Education Research*, *4*(1), 2. https://doi.org/10.1186/s43031-021-00042-x

Muthmainnah, R., Putri, D. I., Kristianti, T., & Aris, S. (2025). Pelatihan modul ajar untuk memperkuat PCK guru Biologi: Praktik baik dari MGMP Kabupaten Garut. *Samakta: Jurnal Pengabdian Kepada Masyarakat,* 2(2), 65–76. https://doi.org/10.61142/samakta.v2i2.237

Rehman, N., Huang, X., Mahmood, A., Zafeer, H. M. I., & Mohammad, N. K. (2025). Emerging trends and effective strategies in STEM teacher professional development: A systematic review. *Humanities and Social Sciences Communications*, *12*(1), 32. https://doi.org/10.1057/s41599-024-04272-y

Sarwi, S., Wardani, S., Zulaeha, I., Handoyo, E., Prasojo, B. T., Mukhoiriyah, A. T., Tiara, Y., & Nurhayati, H. (2023). Asesmen pembelajaran IPAS berbasis kecakapan abad ke-21

guru-guru SMP/MTs. *Prosiding Seminar Nasional Pengabdian Masyarakat*, 1. https://doi.org/10.61142/psnpm.v1.86

Silaban, R., Pasaribu, C. J., & Priyanti, D. (2023). Penguatan kompetensi guru berbasis ICT di Sekolah UPT SD 030290 Punguan Nauli Kecamatan Sitinjo. *Prosiding Seminar Nasional Pengabdian Masyarakat,* 1. https://doi.org/10.61142/psnpm.v1.84

Siregar, T., Wirawati, N. P. C., & Kelmaskosu, N. D. S. (2025). Pelatihan pembuatan e-modul pada guru-guru SMA Negeri 7 Jayapura. *Samakta: Jurnal Pengabdian Kepada Masyarakat,* 2(2), 77–83. https://doi.org/10.61142/samakta.v2i2.241.

Supriyadi, S., Lia, R. M., Rusilowati, A., Isnaeni, W., Susilaningsih, E., Suraji, S., Barus, R. A., Sun'an, U. N., Rapi, M., Fardiana, R., & Husain, S. (2023). Program pengabdian masyarakat Unnes: Pelatihan pembelajaran berdiferensiasi dan asesmennya bagi guru SD. *Prosiding Seminar Nasional Pengabdian Masyarakat,* 1. https://doi.org/10.61142/psnpm.v1.98

Surahman, E., & Wang, T.-H. (2023). In-service STEM teachers professional development programmes: A systematic literature review 2018–2022. *Teaching and Teacher Education*, *135*, 104326. https://doi.org/https://doi.org/10.1016/j.tate.2023.104326

Wahono, B., Lin, P.-L., & Chang, C.-Y. (2020). Evidence of STEM enactment effectiveness in Asian student learning outcomes. *International Journal of STEM Education*, *7*(1), 36. https://doi.org/10.1186/s40594-020-00236-1

Widoretno, S., Prabowo, C., & Hardiana, N. (2023). Teacher's questions in project-based learning: the impact on the quality of student's concept map components. *Research and Practice in Technology Enhanced Learning*, *18*, 031. https://doi.org/10.58459/rptel.2023.18031

Widarti, H. R., Munzil, Rahayu, S., Setiawan, N. C. E., Rokhim, D. A., Pratiwi, J. K., Peni, R., & Wahyudi, A. (2024). Analisis konten dan materi kegiatan pengabdian pendampingan peningkatan kompetensi pendidik kelompok MGMP Kimia Sidoarjo: Studi pendahuluan. *Samakta: Jurnal Pengabdian Kepada Masyarakat*, 1(1), 8–15. https://doi.org/10.61142/samakta.v1i1.30