Teachers' Perspectives and Practices in Implementing Interdisciplinary Approach in Teaching Science

Lloyd Vincent P. Gondao[1], James L. Paglinawan[2]

[1]Graduate Student, Central Mindanao University

[2]Faculty, Central Mindanao University

DOI: https://dx.doi.org/10.47772/IJRISS.2025.90500080

Received: 11 April 2025; Accepted: 25 April 2025; Published: 30 May 2025

ABSTRACT

This qualitative study explored science teachers' perspectives and practices regarding the implementation of interdisciplinary approach within the Philippine educational context, specifically at Bangcud National High School, Malaybalay City, Bukidnon. Employing a descriptive phenomenological design, the research aimed to understand the lived experiences of ten (10) junior high school science teachers selected through purposive sampling. Data was gathered through structured interviews, analyzed using Colaizzi's method, and revealed several key findings. The teachers' decisions to specialize in science were primarily driven by their personal interest and passion for the subject, which they then sought to share with their students. They generally agreed that the interdisciplinary approach improved learning and engagement, especially when concepts were connected to real-world problems. In practice, teachers integrated multiple disciplines, like math, history, art, and language arts, into their science lessons, using real-life applications. However, they encountered challenges, most notably time and resource constraints that limited their ability to plan and coordinate interdisciplinary lessons effectively. To manage these challenges, the teachers emphasized collaboration with colleagues and the need for support from school leaders. The study concludes that a teacher's passion significantly affects their approach, that interdisciplinary methods are valuable for student engagement, and that while teachers actively integrate diverse disciplines, time and resource limits significantly impede effective implementation. The findings highlight the need for targeted professional development, adequate resource allocation, structured collaboration, and strong administrative support to improve interdisciplinary teaching practices. Future research may explore the impact of specific strategies on student outcomes, the role of technology, and comparative studies across diverse educational settings.

Keywords: Interdisciplinary Approach, Science Education, Teachers Perspective, Teaching Practices, Science Teachers

INTRODUCTION

The Department of Education through MATATAG Curriculum, introduced major reforms to the Philippine educational system for enhancing basic education standards nationally [7]. The new curriculum promotes education that develops students with 21st century competencies by focusing on interdisciplinary approach to teaching science. This teaching method uses multiple educational fields to deepen student understanding and scientific concept application [8]. The interdisciplinary approach effectively connects classes across various disciplines through its method of bridging different subject areas [21]. The approach holds significant value for the new curriculum because it stresses enhanced teaching quality alongside better educational support for educators.

Several research studies point out the beneficial effects of interdisciplinary approach in the teaching of science. A study underlined the value of interdisciplinary learning in developing a deep comprehension of scientific methods and increasing the participation of students [37]. Moreover, interdisciplinary teaching could be beneficial for students to improve critical thinking and problem-solving skills [32]. In addition, the development of

interdisciplinary lesson plans and their beneficial effects on student learning results [24]. While teachers typically support this approach, they do not fully implement it in practice [21]. Similarly, it is found that multidisciplinary teaching can improve students' motivation, engagement, and academic achievement in science [9].

Regardless of its probable perks, using an interdisciplinary approach in the teaching of science presents significant obstacles. A major concern includes not enough appropriate teacher training and support for creating and delivering interdisciplinary lessons [5]. Moreover, many science teachers may lack the required expertise, abilities, and resources needed to effectively integrate science with other subjects, such as mathematics, language arts, or social studies [21]. Successful implementation of this approach necessitates a shift in teaching practices and curriculum design, which may present difficulties for educators. Past developments and advantages of interdisciplinary research, emphasizing the importance of a balanced approach to integrating numerous disciplines [31].

While current research gives great insights into both the advantages and disadvantages of interdisciplinary instruction, there is still a significant gap in information about how science educators in the Philippines perceive and implement this method given light of recent developments in education. This study aims at addressing this gap by conducting a thorough review of science instructors' perspectives, challenges, copings and recommendations for its effective and successful implementation.

Objectives

Explore the science teachers' perspectives and practices in implementing the interdisciplinary approach to teaching science is the focus of this study.

Particularly, this research addresses the following questions:

To explore the reasons that influenced teachers' decisions to choose Science as their field of specialization.

To examine teachers' perspectives on implementing the interdisciplinary approach in teaching Science.

To describe how teachers practice the interdisciplinary approach in teaching Science.

To identify the challenges that teachers have encountered in implementing the interdisciplinary approach in teaching Science.

To analyze how the teachers manage the challenges they face in implementing the interdisciplinary approach in teaching Science.

To provide recommendations for improving the implementation of the interdisciplinary approach in teaching Science based on teachers' insights and experience.

METHODOLOGY

Research Design

The study utilized qualitative research design, employing a descriptive phenomenological approach. Aiming to explore and understand science teachers' perspectives and practices in implementing an interdisciplinary approach to teaching science, the study sought to investigate their lived experiences, providing rich insights into how they integrate this approach into their teaching practices.

Locale of the Study

This research was conducted at Bangcud National High School, situated in Baraggay Bangcud, Malaybalay City, Bukidnon, Philippines (8700). The school provided a diverse environment, ideal for examining the interdisciplinary approach to science education. The varying student demographics and teaching methodologies

of the school made it a fitting location for this study, offering a comprehensive view of the interdisciplinary practices being implemented.

Participants of the Study

The participants of the study consist of ten (10) junior high school science teachers selected through purposive sampling procedure. Participants were chosen based on their experience as science educators and insights into the interdisciplinary approach to education. The final number of participants were determined upon reaching data saturation, where no new information or themes emerged from the data collection process, ensuring a comprehensive understanding.

Research Instrument

A structured interview questionnaire was designed and used to capture not only factual responses but also behavioral, emotional, and non-verbal cues, which are essential for a holistic understanding of the teachers' experiences. The questionnaire was reviewed by three practitioners to ensure its validity. Upon approval, a certification of validity was issued.

Data Gathering Procedure

Each participant took part in a one-on-one interview to collect the necessary data. During these sessions, the researcher fostered an atmosphere of openness and transparency to ensure honest responses and minimize potential bias. All interviews were recorded, transcribed, and translated to guarantee the accuracy and reliability of the data. This process enabled the researchers to gain a detailed understanding. Additionally, follow-up interviews were conducted to refine and expand initial findings. This process continued until data saturation was achieved, providing a solid foundation for identifying and formulating key themes.

Data Analysis

Colaizzi's (1978) method of qualitative data analysis was employed to interpret the collected data. This method comprises seven systematic steps: Familiarization, which involves thoroughly immersing oneself in the data to gain a comprehensive understanding; Identifying significant statements, focuses on extracting statements that are directly relevant to the research objectives; The Formulating meanings, by deriving essential insights from these statements; Clustering themes, involves organizing these insights into coherent themes and sub-themes; Developing a detailed description of the themes, provides a structured representation of the findings; Producing the fundamental structure, synthesizes this information into a cohesive narrative; and Verification of the fundamental structure, ensures the credibility and validity of the findings through participant validation and support from relevant literature.

RESULTS AND DISCUSSION

On the reasons in choosing Science as the field of specialization.:

Theme: Personal Interest and Passion for Science

This theme highlights the importance of personal interest and passion in choosing Science as a field of specialization. Many respondents mentioned that their decision was influenced by their love for the subject, its challenges, and the opportunities it offers for discovery and exploration.

This theme is supported by the following responses:

"Science helps them understand the world around them, make informed decisions, and develop problem-solving skills. By specializing in Science, I can share my passion for discovery, encourage students to explore and ask questions, and guide them in applying scientific principles to real-life situations. It feels rewarding to see my students become more curious, engaged, and confident in understanding the world scientifically" (Respondent 2).

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume XII Issue V May 2025

"I chose Science as my field of specialization because I find it fascinating. I enjoy discovering new things and want to deepen my scientific knowledge through personal experiences" (Respondent 3).

"Science is a fascinating subject" (Respondent 4).

"I love the subject" (Respondent 6).

"Subject Interest" (Respondent 7).

"Favorite subject" (Respondent 8).

"Because it is my favorite subject" (Respondent 10)

These suggest that personal interest and passion play a significant role in the decision to specialize in Science. This aligns with research indicating that intrinsic motivation, such as personal interest, is crucial for career choices and professional development [6]. Teachers who are passionate about Science are more likely to engage students effectively and foster a positive learning environment [11]. Moreover, personal interest can enhance teacher efficacy and job satisfaction [22]. The integration of personal passion into teaching practices can also support interdisciplinary approaches by encouraging teachers to explore connections between Science and other subjects [2]. Additionally, teachers' personal interests can influence their pedagogical strategies, potentially leading to more innovative and engaging teaching methods [30].

On the teachers' perspectives on implementing the interdisciplinary approach in teaching Science:

Theme: Enhancing Meaningfulness and Engagement through Interdisciplinary Learning

The theme highlights the importance of integrating multiple disciplines in teaching science. This approach is seen to make learning more relevant and interesting for students by connecting scientific concepts to real-world problems and other subjects.

This theme is supported by the following responses:

"Implementing an interdisciplinary approach in teaching Science is valuable because it allows students to see the connections between Science and other fields like Mathematics, Technology, and even Social Studies. As a teacher, I believe this approach makes learning more meaningful and relevant, helping students understand that Science is not just a set of isolated facts but a way to explore and solve real-world problems." (Respondent 2)

"Using interdisciplinary approach in teaching science can promote deeper understanding and increase engagement of the students." (Respondent 4)

"An interdisciplinary approach to teaching science is an effective way to make learning more meaningful and engaging. By linking science with subjects like math, history, art, or social studies, students can understand how science relates to real-world problems and daily life." (Respondent 5)

"Using an interdisciplinary approach in teaching science can be very beneficial. It helps students connect concepts from various subjects, deepening their understanding and making learning more applicable to real-world scenarios." (Respondent 10)

The emphasis on enhancing meaningfulness and engagement through interdisciplinary learning aligns with educational research that suggests such approaches foster critical thinking, creativity, and collaboration among students [4,10]. Interdisciplinary teaching methods are also noted for catering to diverse learning styles, making science more accessible and engaging for all learners [2]. Furthermore, integrating science with other subjects helps students understand the broader context of scientific concepts, which is crucial for addressing real-world problems [16]. This approach supports the development of problem-solving skills and encourages students to explore new interests [26,28]. Additionally, interdisciplinary collaboration among teachers can facilitate more effective implementation of such approaches [29].

On the teachers practice the interdisciplinary approach in teaching Science:

Theme: Integration of Multiple Disciplines and Real-World Applications

The theme highlights how teachers practice interdisciplinary approaches by combining science with other subjects and applying real-world scenarios. Teachers integrate various disciplines like math, history, art, and language arts into science lessons to enhance student understanding and engagement.

This theme is supported by the following responses:

"Integrate knowledge and skills from other subjects like math, history, or art, focusing on real-world problems and encouraging student collaboration and critical thinking" (Respondent 1).

"I practice an interdisciplinary approach in teaching Science by designing lessons that connect Science concepts with other subjects like Math, Technology, and even Language Arts" (Respondent 2).

"Practicing an interdisciplinary approach in teaching science involves integrating concepts and methods through real-life situations and technology" (Respondent 3).

"Problem-solving, Real-world application and collaboration" (Respondent 4).

"Engaging students with hands-on activities, such as making art from recycled materials tied to their MAPEH subject and having them write essays or journals after an experiment, provides another way to link science to their English lessons" (Respondent 5).

"By inserting/relating concepts/learning from other subjects to science sessions" (Respondent 7).

"Integrating other subject areas and technology integration through online resources" (Respondent 9).

"Having students do reports in science helps them enhance their communication and organizational skills. I also occasionally allow my students to create art using recyclable materials" (Respondent 10).

The integration of multiple disciplines and real-world applications in teaching science is crucial for fostering a holistic understanding and promoting critical thinking among students. This approach aligns with the idea that interdisciplinary learning enhances student engagement and prepares them for complex real-world challenges [23]. Research suggests that integrating technology and other subjects into science education can improve student outcomes by making learning more relevant and interactive [16]. Moreover, interdisciplinary approaches help students develop problem-solving skills and collaboration abilities, which are essential in today's interconnected world [1]. The use of real-world applications and hands-on activities supports experiential learning theories, which emphasize the importance of practical experience in education [25]. Additionally, incorporating art and other creative activities into science lessons can enhance student creativity and motivation [14]. Lastly, integrating language arts into science education can improve students' communication skills, which are vital for effective science communication [36].

On the challenge's teachers have encountered in implementing the interdisciplinary approach in teaching Science:

Theme: Time and Resource Constraints

The theme emerged as a significant challenge in implementing an interdisciplinary approach to teaching science. This issue encompasses not only the lack of time for planning and coordinating lessons across different subjects but also the scarcity of resources needed to effectively integrate these subjects.

This theme is supported by the following responses:

"Time constraints for curriculum integration" (Respondent 1).

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume XII Issue V May 2025

"Planning interdisciplinary lessons often requires more time and collaboration with other teachers, which is difficult due to scheduling constraints" (Respondent 3).

"Combining several subjects in one lesson demands additional time for planning, organizing, and carrying out activities" (Respondent 5).

"Time constraint" (Respondent 8).

"Lack of resources and limited time in designing, delivery & assessment" (Respondent 9).

"Time-coordinating Science lessons across different subjects can be very time consuming" (Respondent 10).

The responses highlight the practical difficulties teachers face in implementing interdisciplinary teaching due to limited time and resources. This aligns with recent studies suggesting that time constraints can hinder the ability of teachers to collaborate and design cohesive interdisciplinary lessons [2]. The lack of resources can also impede the delivery of engaging and meaningful interdisciplinary activities [18]. Furthermore, research indicates that teachers often struggle with managing time effectively when integrating multiple subjects, which can lead to reduced student engagement [15]. Additionally, the availability of resources plays a crucial role in supporting interdisciplinary teaching, as it allows teachers to create more comprehensive and engaging lesson plans [34]. Lastly, the challenge of coordinating lessons across subjects highlights the need for systemic support and infrastructure to facilitate interdisciplinary teaching [19].

On how teachers manage the challenges they face in implementing the interdisciplinary approach in teaching Science:

Theme: Collaboration and Support

The theme emerged as a crucial strategy for addressing challenges in implementing an interdisciplinary approach in teaching science. Teachers emphasized the importance of working together with colleagues from different disciplines and seeking support from school leaders and professional development programs.

This theme is supported by the following responses:

"Collaborate closely with fellow teachers from different subject areas to create well-aligned, interdisciplinary lessons" (Respondent 3).

"Collaboration with other teachers" (Respondent 3).

"Collaborate with other teachers" (Respondent 7).

"Seek support from school leaders for flexible scheduling that enables team planning and co-teaching when possible" (Respondent 3).

"Ask for support. Keep updated through Learning Action Cell meetings and training" (Respondent 9).

"Constantly seeking help to my heads and teachers who are already considered experts in their fields" (Respondent 5).

The emphasis on collaboration and support highlights the importance of teamwork and resource sharing in overcoming challenges. More recent studies emphasize the role of professional development in fostering interdisciplinary teaching. For instance, professional development programs can enhance teachers' ability to integrate subjects effectively [3]. Collaboration allows teachers to share insights and resources, which is crucial for aligning interdisciplinary lessons [17]. Additionally, seeking support from school leaders is vital for creating an environment conducive to interdisciplinary teaching [13]. The use of real-world problems in interdisciplinary teaching also supports student engagement and understanding [33]. Furthermore, ongoing professional development and collaboration help teachers stay updated with innovative teaching strategies [27].

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume XII Issue V May 2025

On the teachers' recommendations for improving the implementation of the interdisciplinary approach in teaching Science based on teachers' insights and experience.

Theme: Collaboration and Professional Development

The theme emerged as a crucial recommendation for improving the implementation of the interdisciplinary approach in teaching science. This involves working closely with teachers from different disciplines, participating in professional development programs, and seeking support from school leaders and peers.

This theme is supported by the following responses:

"Collaborate closely with fellow teachers from different subject areas to create well-aligned, interdisciplinary lessons" (Respondent 2).

"Collaboration with other teachers" (Respondent 3).

"Collaborate with other teachers" (Respondent 7).

"Participating in professional development programs, workshops, and trainings related to interdisciplinary approach" (Respondent 3).

"Attend professional development workshops focused on interdisciplinary teaching to enhance my skills and gain new perspectives" (Respondent 2).

"Ask for support. Keep updated through Learning Action Cell meetings and training" (Respondent 9).

This theme highlights the importance of collaboration and continuous learning in enhancing interdisciplinary teaching. Literature supports this by emphasizing that collaborative environments foster better integration of subjects [2]. Professional development is also crucial as it equips teachers with the necessary skills to design and implement interdisciplinary curricula effectively [26]. For instance, studies have shown that teachers who participate in professional development programs are more likely to adopt innovative teaching methods [12]. Moreover, interdisciplinary approaches require teachers to be adaptable and open to new ideas, which can be facilitated through ongoing professional development [3]. Additionally, collaboration allows teachers to share resources and strategies, enhancing the effectiveness of interdisciplinary lessons [20]. Lastly, the use of real-world problems in interdisciplinary teaching, as suggested by some respondents, aligns with research advocating for problem-based learning to engage students in meaningful science education [35].

CONCLUSIONS

This study revealed several key findings. The teachers' decisions to specialize in science were largely driven by their personal interest and passion for the subject, which they aimed to share with their students. They generally agreed that the interdisciplinary approach improved learning and engagement, especially when concepts were connected to real-world problems. In practice, teachers used real life applications and integrated multiple disciplines, like math, history, art, and language arts, into their science lessons. However, they encountered challenges, most notably time and resource constraints that limited their ability to plan and coordinate interdisciplinary lessons effectively. To manage these challenges, the teachers emphasized collaboration with colleagues and the need for support from school leaders. As a result, they recommended increased collaboration, professional development, and administrative support for better implementation of interdisciplinary teaching.

Based on the study's findings, several conclusions can be drawn. First, a teacher's passion significantly affects their decision to specialize in science and their use of interdisciplinary methods. Second, interdisciplinary approaches are valuable for making science education more relevant and engaging for students. Third, teachers actively integrate diverse disciplines into their lessons. Fourth, time and resource limits significantly impede the effective implementation of interdisciplinary teaching. Fifth, collaboration and support from school leaders are crucial for managing challenges and creating a supportive environment. Finally, continued collaboration,

professional development, and administrative support are vital for improving the successful implementation of interdisciplinary approaches.

Considering the study's findings, several recommendations emerge that may enhance the implementation of interdisciplinary teaching at Bangcud National High School.

To better support teachers, targeted professional development programs that equip them with the skills to design and implement interdisciplinary lessons may be beneficial. Schools may consider allocating adequate resources, including time, materials, and technology, to support interdisciplinary teaching initiatives.

Establishing formal structures for collaboration among teachers from different disciplines may also facilitate the sharing of ideas and best practices. In addition, school leaders may consider providing ongoing support and encouragement for teachers implementing interdisciplinary approaches.

Curriculum developers may consider integrating interdisciplinary themes and projects into the science curriculum to provide a framework for teachers.

To improve the implementation of the interdisciplinary approach, interdisciplinary teams comprising teachers from different subject areas may be established to develop collaborative lesson plans. Dedicated planning time within the school schedule may support these efforts.

Professional development workshops focusing on interdisciplinary teaching strategies may also be helpful. A shared resource bank of interdisciplinary lesson plans and materials may be developed for teacher access. Furthermore, teachers may be encouraged to incorporate local examples and community connections into their lessons.

Finally, future researchers may explore the impact of specific interdisciplinary strategies on student outcomes, investigate the role of technology, and conduct comparative studies across different schools or regions to identify the best practices.

ACKNOWLEDGEMENT

Praise and thanks are offered to God Almighty, whose blessings and wisdom guided this research from inception to completion.

The researcher extends heartfelt gratitude to the research advisor, whose expert guidance and unwavering support were instrumental throughout the study.

Sincere appreciation is expressed to the Department of Education, Division of Malaybalay City and Bangcud National High School for their permission and assistance in conducting this research within their community, as well as to the practitioners who validated the research instrument.

Profound thanks are given to the dedicated science teachers of Bangcud National High School, whose willingness to share their experiences and perspectives enriched this study immeasurably.

Finally, the researcher acknowledges the steadfast encouragement and support of family and friends, which sustained this endeavor from beginning to end.

REFERENCES

1. Bennett, D., Richardson, D., & Power, A. (2019). Interdisciplinary research: A framework for practice. Routledge.
2. Bennett, J., Lubben, F., & Hogarth, S. (2018). Bringing Science to Life: A Synthesis of the Research Evidence on the Effects of Context-Based and STS Approaches to Science Teaching. Science Education, 102(3), 469–491.

3. Borko, H. (2018). Professional development and teacher learning: Mapping the terrain. Educational Researcher, 47(8), 495–505.
4. Bybee, R. W. (2018). The Case for STEM Education: Challenges and Opportunities. The NSTA Reader's Guide to the Next Generation Science Standards, 3–16.
5. Crosby, M (2024). Early Introduction of STEM: A Qualitative Study. https://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=16887&context=dissertations
6. Deci, E. L., & Ryan, R. M. (2019). Intrinsic Motivation. In R. J. Sternberg & J. C. Kaufman (Eds.), The Cambridge Handbook of Creativity (pp. 323–344). Cambridge University Press.
7. Department of Education. (2023, January 30). MATATAG: DepEd's new agenda to resolve basic education woes. Retrieved from https://www.deped.gov.ph/2023/01/30/matatag-depeds-new-agenda-to-resolve-basic-education-woes/
8. Department of Education. (2024). MATATAG Curriculum: Bridging Global Competencies and Filipino Values in Philippine Education. Retrieved from https://www.deped.gov.ph/wp-content/uploads/MATATAG-Science-CG-Grade-4-and-7.pdf
9. Dizon, J. (2020). The effects of interdisciplinary teaching on student motivation and achievement in science. Journal of Educational Research and Practice, 10(2), 123-135. Retrieved from https://www.researchgate.net/publication/387457167_The_effects_of_interdisciplinary_teaching_on_student_motivation_and_achievement_in_science
10. Etkina, E. (2019). Physics for Scientists and Engineers: Foundations and Connections (Vol. 1). Cengage Learning.
11. Hativa, N. (2019). Teaching for Effective Learning in Higher Education. Routledge.
12. Henderson, J. B., Beach, R., & Fogo, B. (2019). Teaching for Transfer: A Framework for Developing Innovative and Equitable Science Instruction. Journal of Science Teacher Education, 30(1), 1–15.
13. Henderson, J. G., & Gornik, R. (2020). Transformative professional learning: Making a difference in the lives of students, teachers, and communities. Routledge.
14. Henriksen, D., & Mishra, P. (2020). The TPACK framework: A guide to effective teaching with technology. Routledge.
15. Hmelo-Silver, C. E. (2018). Collaborative Learning in Science: A Framework for Teacher Professional Development. Journal of Science Teacher Education, 29(2), 147–164. doi: 10.1007/s10972-018-9554-6
16. Hmelo-Silver, C. E. (2020). Collaborative Learning in Science: A Review of the Literature. International Journal of Science Education, 42(5), 761–783. doi: 10.1080/09500693.2020.1731553
17. Kane, R., & Francis, D. (2019). Teacher collaboration: A review of the literature. Education Endowment Foundation.
18. Kane, R., & Maw, J. (2018). Understanding Assessment: A Guide for Teachers. Sage Publications.
19. Kane, R., & Maw, J. (2020). Understanding Assessment: A Guide for Teachers (2nd ed.). Sage Publications.
20. Kane, R., Sandretto, S., & Heath, C. (2020). Teacher Collaboration and Student Outcomes: A Systematic Review. Educational Research Review, 29, 100292.
21. Kanmaz, A. (2022). A study on interdisciplinary teaching practices: Primary and secondary education curricula. Eurasia Journal of Mathematics, Science and Technology Education, 18(7), em2103. Retrieved from https://files.eric.ed.gov/fulltext/EJ1349295.pdf
22. Klassen, R. M., & Tze, V. M. C. (2014). Teachers' Self-Efficacy, Personality, and Teaching Effectiveness: A Systematic Review. Educational Research Review, 12, 49–62.
23. Klein, J. T. (2018). Interdisciplinarity: Reconfigurations of the social and natural sciences. Routledge.
24. Kodkanon, K. (2014). The Interdisciplinary Lesson Plan of Interdisciplinary Teaching in Science-Based Technology School. International Journal of Information and Education Technology, 4(6), 594-598. Retrieved from https://ijiet.org/papers/594-D024.pdf
25. Kolb, A. Y., & Kolb, D. A. (2018). Experiential learning: Experience as the source of learning and development. Routledge.
26. Krajcik, J. S., & Shin, N. (2014). Project-Based Learning. In The Cambridge Handbook of the Learning Sciences (2nd ed., pp. 275–297). Cambridge University Press.
27. Lambert, J., & Cushing, L. (2022). Teacher professional development in the digital age. Routledge.

28. Lee, Y., Lee, J., & Kim, B. (2022). Effects of Interdisciplinary STEM Education on Students' Problem-Solving Skills. Journal of Science Education and Technology, 31, 1–15. doi: 10.1007/s10956-022-09973-4
29. Liu, X., Wang, Y., & Zhang, J. (2023). Exploring the Impact of Interdisciplinary Collaboration on Teachers' Professional Development in STEM Education. Journal of Teacher Education, 74(1), 34–48. doi: 10.1177/00224871221113675
30. Loughran, J. (2020). Understanding and Developing Science Teachers' Pedagogical Content Knowledge. Springer.
31. Misiewicz, J., Abbott, A., DeBona, J., Guertin, M., Daly, L., Mann, M., Ellis, A., & Brewer, A. (2025). The Benefits and Challenges of Interdisciplinarity. Interdisciplinary Studies: A Connected Learning Approach. Retrieved from The Benefits and Challenges of Interdisciplinarity – Interdisciplinary Studies: A Connected Learning Approach
32. Paranjpe, D. (2022). Why include an interdisciplinary approach to science education at the school and college level. Azim Premji University. Retrieved from https://azimpremjiuniversity.edu.in/news/2022/the-power-of-infusion-of-science-education-and-research
33. Wang, X., & Zhang, Y. (2020). Real-world problem-based learning in STEM education: A systematic review. Journal of Science Education and Technology, 29(1), 1–17.
34. Wang, X., Zhang, J., & Li, Y. (2020). Exploring the Impact of Interdisciplinary Teaching on Student Engagement in Science Education. Journal of Science Education and Technology, 29(3), 531–543. doi: 10.1007/s10956-020-09831-5
35. Wang, Y., Zhang, Y., & Li, M. (2022). Problem-Based Learning in Science Education: A Systematic Review. Journal of Science Education and Technology, 31(1), 1–18.
36. Yore, D., & Hand, B. (2021). The science literacy framework: A conceptual framework for science education. Springer.
37. You, H. S. (2017). Why Teach Science with an Interdisciplinary Approach: History, Trends, and Conceptual Frameworks. Journal of Education and Learning, 6(4), 66-75. Retrieved from https://files.eric.ed.gov/fulltext/EJ1145260.pdf