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Differentiated Instruction Based on Learning Styles in Chemistry Classrooms: A Systematic Review of Models, Outcomes, and Implementation Challenges

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Abstract
This systematic literature review explores the integration of learning-style-based differentiated instruction with active learning models, particularly Problem-Based Learning (PBL) and Project-Based Learning (PjBL), in secondary chemistry education. The purpose of the review is to identify, synthesize, and critically analyze how a differentiated learning approach based on learning styles can be effectively activated with active learning models such as PBL and PjBL in the context of secondary chemistry education. Drawing on eleven peer-reviewed studies published between 2015 and 2025, the review identifies how differentiation strategies, when aligned with students' visual, auditory, and kinesthetic preferences, can enhance conceptual understanding, motivation, and critical thinking. The review reveals consistent positive outcomes across various learning domains, with differentiation applied through content, process, and product adjustments. However, it also uncovers persistent implementation challenges, including limited teacher training, resource constraints, and lack of institutional support. The situation analysis finds these findings within the frameworks of constructivist pedagogy and responsive teaching, emphasizing the importance of adaptable, student-centered instruction in chemistry education. The study concludes by recommending stronger systemic support, longitudinal research, and professional development to ensure the sustainable application of differentiated instruction in diverse chemistry classrooms.

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INTRODUCTION

Chemistry is often perceived as a challenging subject by students (Fajrin et al., 2020), primarily because its content involves abstract concepts that require understanding at multiple levels, i.e., macroscopic, microscopic, and symbolic. Many students struggle to connect these representations, which are crucial for understanding chemical phenomena (Holme & Murphy, 2012). This difficulty can lead to confusion, low confidence, and a general decline in interest and academic achievement in chemistry. Sedeṅo et al. (2021) found that when teachers use the same teaching method for all students, without considering individual differences in how students learn, it tends to exacerbate these problems. In Indonesia, although the 2013 Curriculum and the newer Merdeka Curriculum promote 21st-century skills and more student-centered learning, traditional lecture-based methods are still dominant in many classrooms (Samura, 2019).

To help overcome these issues, one approach that has gained attention is differentiated instruction (Marantika et al., 2023). This method is based on the understanding that students have diverse learning styles and therefore benefit from teaching strategies that consider their readiness, interests, and learning profiles (Subban, 2006; Tomlinson, 2014). Rather than applying the same method to all learners, differentiation aims to make learning more responsive and inclusive (Subban, 2006; Tomlinson, 2014). In science education, especially in chemistry, where students must grasp complex and abstract concepts, this approach can be beneficial. It supports students not only in understanding key concepts but also in developing essential skills, such as critical thinking, problem-solving, and laboratory work (Minarni et al., 2024; Wardani et al., 2024). Salar & Turgut (2021) also observed that students who learned in differentiated classrooms felt more confident and took a more active role in science learning.

A practical way to begin applying differentiated instruction is by recognizing students' learning styles, such as visual, auditory, and kinesthetic (Cuevas, 2015; Maher et al., 2023). When teachers design lessons that align with these preferences (Fadhila et al., 2024), students are more likely to participate actively and remain motivated in class (Anggraini et al., 2024). Still, many teachers find it difficult to adjust their teaching methods, especially without clear guidance or structured support. Lavania & Nor (2020) highlight that time constraints, limited resources, and a lack of training often become significant barriers in classrooms that attempt to implement differentiated strategies.

To support teachers and make differentiation more effective, some educators have turned to active learning models like Problem-Based Learning (PBL) and Project-Based Learning (PjBL) (Nestiyarum & Widjajanti, 2023; Safitri & Haryani, 2025). These models offer students the opportunity to collaborate, explore real-world problems, and express their learning in various ways. When combined with differentiation, they enable the flexible use of learning materials, classroom tasks, and methods for students to demonstrate their knowledge. There has been little research that systematically examines how these two approaches can be combined, particularly in chemistry lessons.

Most existing studies focus on either active learning or differentiation, but not on how these approaches can be combined. For example, Wahyuni et al. (2023) studied the benefits of PBL in chemistry, but didn't consider students' different learning styles. Prima & Abdurahman (2024) compared PjBL and Discovery Learning, while (Juliani et al., 2024; Rohim et al., 2024) explored readiness-based differentiation; however, neither of these studies examined how the two strategies might be combined. These gaps indicate that further research is necessary to bridge the gap between theory and practice more closely.

Recent work, suggests that combining problem-based learning (PBL) and differentiation enhances students' ability to analyze and interpret experimental data, a crucial skill in chemistry (Nestiyarum & Widjajanti, 2023; Safitri & Haryani, 2025). These models not only provide a framework for meaningful and collaborative learning contexts but also enable flexible differentiation of content, process, and products. In this combined framework, students can engage with material in ways that match their preferences while also fostering learner autonomy, reflective thinking, and metacognitive skills.

Nevertheless, to date, there has been no systematic literature review that examines explicitly how learning-style-based differentiation is integrated with active instructional models, such as PBL and PjBL, in the context of secondary chemistry education. Most existing studies remain descriptive and focus on single strategies or models without exploring the combinatory potential or thematic synthesis across approaches. These gaps highlight the absence of strategic and theoretical integration in current chemistry education literature. Additionally, practical challenges such as teachers' lack of preparation, limited access to teaching materials, and the time required for planning are rarely discussed in depth (Muhab et al., 2024). Frerejean *et al.*

(2021) also noted that some teachers remain unfamiliar with the fundamental concepts behind differentiated instruction, thus applying it superficially Frerejean *et al*. (2021). Existing studies are often fragmented and fail to critically synthesize the impact of these strategies across multiple learning domains, including cognitive, affective, and psychomotor (Hasanah, 2019).

Although various studies have proven the effectiveness of active learning models such as Problem-Based Learning (PBL) and Project-Based Learning (PjBL), as well as differentiated instruction approaches in improving student engagement and learning achievement, no systematic review has explicitly explored the integration of both based on students' learning styles in the context of secondary chemistry education.

This gap includes several important aspects, such as the limited number of structured literature reviews critically discussing the implementation of integrated differentiated approaches and problem/project-based learning. Furthermore, interdisciplinary research in the learning domain linking the combined impact of these strategies on students' cognitive, affective, and psychomotor domains is still very limited. Existing research often focuses solely on cognitive aspects, without considering how this combined model can shape students' scientific attitudes or practical skills

Thus, research is needed that not only describes the effectiveness of each approach but also develops an explicit and systematic framework on how learning-style-based differentiation can be designed and implemented within the context of PBL or PjBL to improve the quality of secondary school chemistry education.

In Indonesia, the importance of differentiated instruction is clearly stated in the Merdeka Curriculum (Suryanti et al., 2025). However, even with this support from policy, many science teachers still struggle to apply differentiation consistently. According to a national survey (Kemdikbudristek, 2023), only 32% of secondary science teachers feel confident in regularly using this approach. This highlights a significant gap between policy and practice, emphasizing the need for sustained professional development and effective teacher support systems.

To better understand and respond to these gaps, this study conducts a systematic literature review (SLR) that aims to: 1) Identify and categorize chemistry instructional models that integrate learning-style-based differentiation; 2) evaluate the effects of these approaches on student learning outcomes, including conceptual understanding, motivation, and practical skills; 3) analyze the challenges and opportunities associated with implementing these combined approaches in secondary chemistry classrooms.

This review synthesizes current knowledge and helps construct a clearer understanding of how active learning and differentiated instruction can be integrated in chemistry education. The primary contribution of this paper is a practical framework that demonstrates how these strategies interconnect and can be utilized to create more inclusive and effective science classrooms. The results are expected to support future curriculum design and teacher training that is grounded in real classroom needs. The key contribution of this review lies in its integrative mapping of active instructional models, principles of differentiation, and learning style categorizations, which may serve as a foundation for evidence-based curriculum development and teacher training initiatives.

METHOD

This study employed a Systematic Literature Review (SLR) method following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). The SLR aimed to identify, evaluate, and synthesize empirical studies that examined the integration of differentiated instruction based on students' learning styles with active learning models in secondary chemistry education.

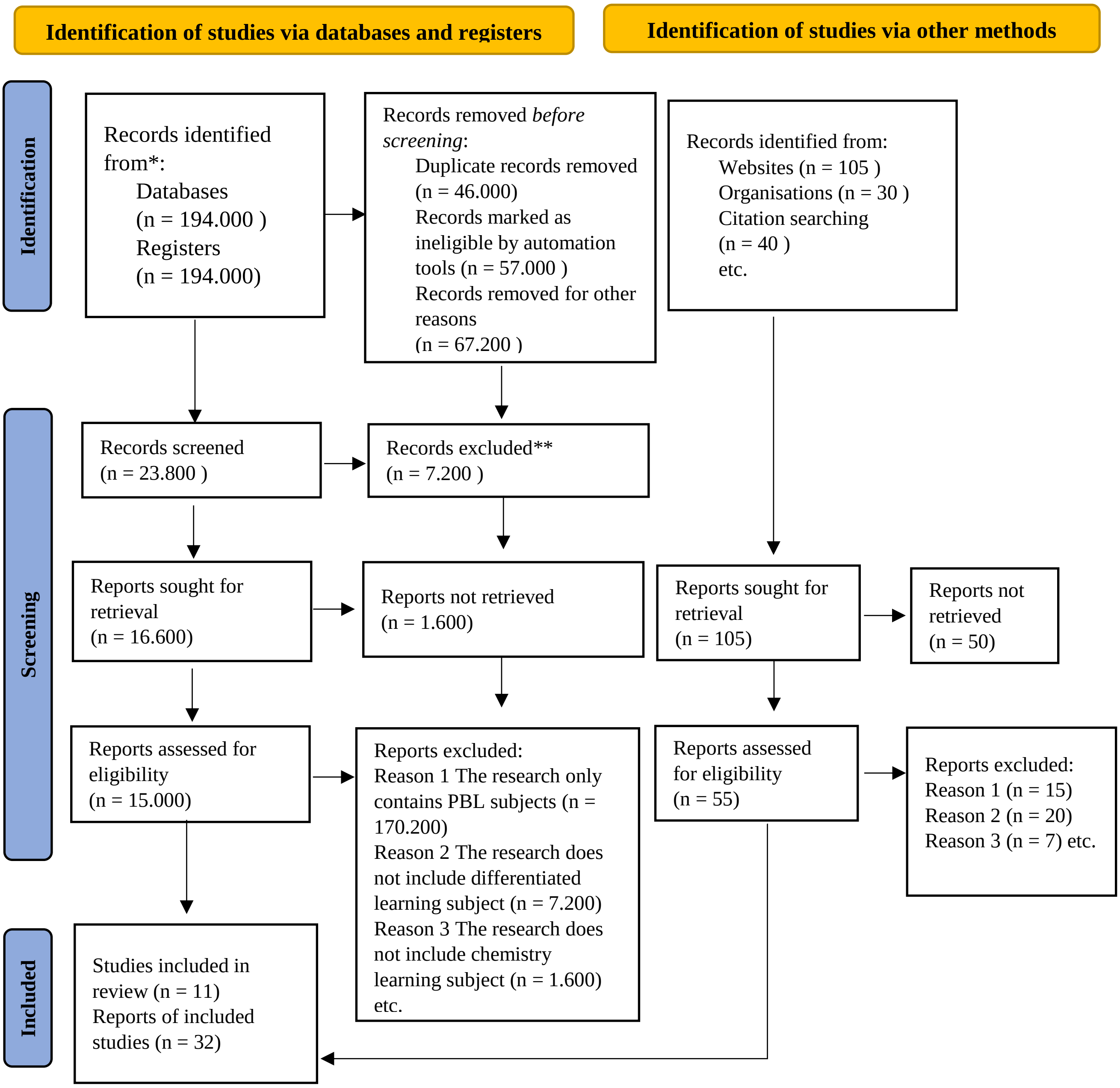

Figure 1. PRISMA flow diagram (Page et al., 2021)

Search Strategy

Relevant studies were identified through a structured search across several academic databases, including Scopus, Web of Science, ERIC, and Google Scholar. The following keywords and Boolean combinations were used: "differentiated instruction" AND "chemistry education," "learning styles" AND "chemistry classroom," "project-based learning" OR "problem-based learning" AND "chemistry education." The search was limited to articles published between 2015 and 2025 to ensure relevance and currency.

Inclusion and Exclusion Criteria

Studies were included if :

a. Were peer-reviewed empirical research articles (quantitative, qualitative, or mixed methods);
b. Focused on secondary school chemistry education;
c. Discussed the use of differentiated instruction based on learning styles;
d. Involved integration with active learning models (e.g., PBL, PjBL, inquiry-based);
e. Full-text.

Studies were excluded if they:

a. Focused solely on higher education or primary school settings;
b. Were theoretical/conceptual papers without empirical data;
c. Did not specifically address chemistry or science as the subject area.

After removing duplicates, titles and abstracts were screened, followed by a review of the full text. The SLR process was documented using a PRISMA flow diagram (see **Error! Reference source not found.**) to ensure transparency and replicability.

Data Extraction and Synthesis

Data from the selected studies were extracted into a coding matrix that included publication details, research design, focus of differentiation, model used, learning outcomes, and key findings (see Table 1). Thematic synthesis was employed to identify recurring patterns, challenges, and outcomes associated with the implementation of differentiated instruction in chemistry education.

RESULTS AND DISCUSSION

Overview of Selected Studies

The final selection included ten empirical studies that examined the use of differentiated instruction based on students' learning styles in chemistry or science classrooms. Summarizes the key characteristics and findings at Table 1.

The reviewed studies predominantly adopted combinations of differentiated instruction with either Problem-Based Learning (PBL) or Project-Based Learning (PjBL). Most were conducted in Indonesian secondary school contexts, with one study from Nigeria (Ojelade et al., 2024) offering a comparative international perspective.

Thematic Synthesis

Impact on Student Learning Outcomes

The impact of differentiation and the role of active learning models first, the results indicate that when learning is tailored to students' learning styles (visual, auditory, or kinesthetic), student engagement, conceptual understanding, and higher-order thinking skills (such as analysis and evaluation) increase significantly. These findings are even stronger, however, when differentiation is combined with active learning models such as Problem-Based Learning (PBL) and Project-Based Learning (PjBL), which are the focus of the second theme. These models provide flexible, contextualized structures, thereby allowing teachers to design learning experiences that are responsive to students' needs.

Table 1. Summary of Reviewed Studies

Author(s)	Year	Study Design	Differentiation Focus	Model Used	Learning Outcome	Key Findings
Jannah *et al*.	2023	Classroom Action Research	Content & Process	PBL	Engagement, Achievement	Differentiated instruction integrated with PBL increased student activity and improved chemistry learning outcomes.
Agustina	2023	Qualitative Case Study	Product	DI only	Meaningful learning, Personalization	Students produced varied outputs aligned with their learning styles; the approach aligned with Merdeka Curriculum and Ki Hajar Dewantara's educational philosophy.
Muhab *et al*.	2024	Descriptive Qualitative	Interest, Readiness, Learning Style	DI only	Engagement, Anxiety Reduction	Differentiated instruction improved student engagement and reduced fear of chemistry, though not all teachers implemented it.
Nestiyarum & Widjajanti	2023	Quasi-Experimental	Process & Product	PjBL	Collaboration, Achievement	PjBL with differentiation improved collaboration (17.11%) and post-test scores (29.38%).
Minarni *et al*.	2024	Quantitative Descriptive	VAK (Content, Process, Product)	PBL	Conceptual Understanding, Motivation	82% of students achieved adequate understanding of acid-base concepts; students responded positively to VAK-based differentiation.
Ojelade *et al*.	2024	Quasi-Experimental	Process	DI only	Achievement, Retention	Significant improvement in academic scores and retention; effective across genders.
Sulistiawati *et al*.	2025	Experimental	Process	PjBL	Critical Thinking	Differentiated PjBL improved critical thinking in acid-base topics.
Wardani *et al*.	2024	Descriptive Qualitative	Contextual, Readiness-based	Culturally Responsive Teaching (CRT)	Chemical Literacy	Integrated CRT and differentiation improved literacy; learning became more meaningful and relevant.
Safitri & Haryani	2025	Quantitative	Learning Style	PBL	Critical Thinking	Average improvement of 60.01% in critical thinking; highest gain (76.82%) in 'moderately skilled' group.
Raehani *et al*.	2023	Classroom Action Research	Process	PBL	Motivation	Student motivation increased significantly from pre-study to cycle II (from 60% to 63.33%).
Astuti	2023	Classroom Action Research	Process	Discovery Learning	Laboratory Skills, Cognitive, Psychomotor, Emotional	Laboratory performance increased to 97%; improvements observed across cognitive, psychomotor, and emotional domains.

The evidence gathered across the reviewed studies supports the idea that when instruction is adapted to align with students' individual learning profiles, meaningful engagement is more likely to occur, particularly in complex subjects such as chemistry. Students who received instruction tailored to their learning styles demonstrated greater involvement, improved motivation, and a deeper understanding of the concepts. For instance, studies reported that visual learners benefited from the use of diagrams and conceptual maps, while auditory learners gained more through discussions and oral explanations, and kinesthetic learners responded well to laboratory-based or hands-on activities (Minarni et al., 2024; Nestiyarum & Widjajanti, 2023; Sulistiawati et al., 2025).

In chemistry, a subject that often requires students to visualize invisible processes and integrate abstract concepts, aligning instructional methods with learning styles becomes not only a pedagogical preference but a necessity. Misconceptions in topics such as chemical bonding, reaction mechanisms, or stoichiometry are reduced when students can process information in a mode that aligns with their cognitive preferences. This finding is consistent with those of Minarni *et al*. (2024) and Sulistiawati *et al*. (2025), who also found that differentiated strategies enhanced conceptual retention.

Furthermore, the integration of differentiation with active learning models amplified these gains. When students were not only learning in a way that matched their profile but were also engaged in problem-solving or project-based contexts, their depth of understanding and confidence in scientific reasoning increased. This supports Tomlinson (2014) framework of responsive teaching, which argues that instruction should be continually adjusted to meet the needs of diverse learners.

Constructivist learning theory also provides a strong underpinning for these outcomes. From a constructivist perspective, students build understanding based on prior knowledge, active involvement, and personal interpretation of experiences. Differentiation enables teachers to scaffold learning in ways that align with these principles, thereby enhancing both cognitive and emotional connections to the content (Cuevas, 2015; Tomlinson, 2014).

Models and Strategies Used

The most commonly used instructional models found in the reviewed studies were PBL and PjBL, both of which were frequently integrated with differentiation strategies. These models provided a flexible and student-centered environment in which instruction could be tailored to meet individual learning preferences. Teachers typically differentiated instruction through three main pathways: content (what students learn), process (how they learn), and product (how they demonstrate learning) (Nestiyarum & Widjajanti, 2023).

In most implementations, teachers first assessed students' preferred learning styles using informal observations, questionnaires, or direct interviews. Based on the results, activities were tailored accordingly. For example, visual learners worked on diagram labeling or visualizing chemical processes through animations (Minarni et al., 2024), while auditory learners participated in structured discussions and recorded reflections (Raehani et al., 2023). Kinesthetic learners, on the other hand, were given hands-on tasks such as assembling molecular models or designing simple experiments (Astuti, 2023).

The use of active learning models such as PBL and PjBL helped create a rich instructional environment that supported this differentiation. Through group investigations, open-ended questions, and authentic tasks, students had multiple entry points to access the material. Nestiyarum & Widjajanti (2023) emphasized that the success of such integration also depended on grouping strategies that allowed learners to collaborate across styles and ability levels.

Several studies also pointed out that culturally responsive teaching enhanced the effectiveness of differentiation. Wardani *et al*. (2024), for instance, incorporated ethnochemical elements into differentiated instruction, making the content more relatable for students and building a stronger connection between their cultural background and the subject matter. These innovations supported student identity and engagement.

Despite the creative practices reported, a recurring limitation was the lack of detailed documentation on how differentiation was planned and executed. Only a few studies explicitly described the process of matching instructional activities to learning styles or explained how they evaluated the effectiveness of such matches. This gap underscores the need for more explicit instructional design guidelines and comprehensive documentation frameworks to support future implementations. However, only a few studies clearly described how learning style assessments were conducted and how differentiation was operationalized in lesson planning.

Despite the promising results, several challenges were consistently reported across the reviewed studies, particularly from the perspective of classroom teachers. A primary concern was the limited time available for designing and implementing differentiated lessons. Creating multiple pathways for content delivery and assessment demands considerable planning, which many teachers, especially those handling multiple classes, found unsustainable (Muhab et al., 2024).

Another significant challenge was the lack of professional development and training. Frerejean *et al*. (2021) found that many teachers had limited or incorrect understanding of what differentiated instruction entails, often interpreting it as simply varying group activities or assigning different worksheets. Without a clear theoretical grounding and practical training, teachers struggle to apply differentiation in meaningful ways, particularly in chemistry, where poorly designed tasks can reinforce misconceptions.

Resource constraints were also frequently cited. Schools with limited access to technology, laboratory equipment, or even basic instructional materials found it difficult to support a range of differentiated activities. This problem was particularly evident in rural or under-resourced contexts. Lavania & Nor (2020) emphasized that effective differentiation is challenging to implement in the absence of materials that support varied learning modes.

Moreover, assessing students' learning styles and readiness levels requires tools and time that many schools do not provide. Teachers often rely on intuition or informal observations, which may not accurately reflect student needs. This lack of diagnostic accuracy can lead to mismatches between student preferences and instructional approaches, thereby reducing the potential benefits of differentiation.

Finally, institutional support, both administrative and curricular, was found to be inconsistent. In some cases, rigid assessment systems or standardized lesson planning formats limited teachers' autonomy to implement differentiated approaches. The findings underscore the importance of a systemic commitment to differentiation, including time allocation, curriculum flexibility, and leadership support, to ensure its sustainability and effectiveness in real classrooms.

These three areas are not isolated, but rather interrelated, illustrating how differentiation can (and cannot) be fully implemented in science education practice. By bringing these three themes together, it becomes evident that the success of differentiation in chemistry education is highly dependent on the alignment between pedagogy, context, and implementer capacity. Without the support of an adaptive learning model, the differentiation approach will easily devolve into merely a symbolic practice. Likewise, without teacher readiness and institutional support, the active model will lose its potential as an inclusion tool. Therefore, the success of this strategy is not determined by a single element, but rather by the interconnectedness and balance among the three. This analysis also emphasizes the importance of a systemic and transformative approach in designing inclusive and sustainable learning innovations in chemistry.

Synthesis with Broader Literature

The themes identified in this review resonate with broader international research on differentiated instruction and its effectiveness in science education. For example, studies in North America and Europe have consistently shown that differentiation, when applied systematically, improves student motivation, achievement, and classroom participation (Tomlinson, 2

014). The findings from Indonesia and Nigeria echo this trend, suggesting a degree of universality in the benefits of matching instruction to diverse student needs.

However, the global discourse also warns against over-reliance on fixed learning styles. Cuevas, (2015) argue that while recognizing preferences is useful, teaching should remain flexible and avoid rigidly assigning students to categories. Instead, teachers should provide a variety of experiences so students can build multiple ways of processing information. This "balanced flexibility" approach was reflected in some of the stronger studies reviewed here, which encouraged all students to engage with tasks outside their preferred modes.

The integration of differentiated instruction with PBL and PjBL aligns well with constructivist pedagogy, which emphasizes active knowledge construction through exploration and collaboration. Across several studies, it was evident that students not only understood chemistry concepts better but also developed metacognitive and social skills, such as planning, teamwork, and communication, when differentiation was combined with inquiry-based models.

Yet, the literature also points to the need for more rigorous empirical evidence. Many of the reviewed studies were limited in scope, lacking control groups or long-term follow-up. Future research should aim to investigate not just the short-term effects but also how differentiated instruction influences students' learning trajectories, resilience, and scientific identity over time.

CONCLUSION

This systematic literature review highlights the positive impact of integrating differentiated instruction, particularly those based on students' learning styles, with active learning models such as PBL and PjBL in chemistry education. Across eleven studies, the synthesis indicates that such integration not only improves academic outcomes like conceptual understanding and critical thinking but also enhances student motivation, engagement, and collaborative competencies. Differentiation in content, process, and product allows chemistry teachers to address classroom heterogeneity in meaningful ways.

The review also reveals that despite the theoretical appeal and practical success of these strategies, implementation remains uneven. Challenges such as insufficient teacher training, limited instructional time, lack of access to diverse learning resources, and institutional rigidity continue to hinder the widespread adoption of differentiated approaches in chemistry classrooms. These issues are particularly pronounced in under-resourced educational contexts, both within Indonesia and beyond.

From a pedagogical perspective, this study affirms the relevance of constructivist theory and responsive teaching in shaping inclusive chemistry learning environments. When instruction is aligned with students' learning preferences and supported by inquiry-driven pedagogies, it creates opportunities for deeper understanding, sustained interest, and improved self-efficacy.

Future research should move beyond short-term gains and investigate the long-term effects of differentiated instruction on students' learning identities, scientific resilience, and performance in standardized assessments. Policymakers and curriculum developers must also provide teachers with structural support, such as professional development, assessment flexibility, and collaborative planning opportunities, to make differentiation a sustainable practice in science education.

This systematic literature review significantly impacts the development of chemistry learning by demonstrating that the integration of differentiated, learning-styles-based instruction with active models such as PBL and PIBI can improve students' conceptual understanding, critical thinking, motivation, and collaboration. This article also highlights implementation challenges in the field, such as a lack of teacher training and limited resources, thus underscoring the need for structural support from education policy. In terms of novelty, this study explicitly combines differentiation strategies with active learning approaches in the context of chemistry and emphasizes the importance of constructivist theory and responsive teaching in creating inclusive classrooms. Furthermore, the call for longitudinal research on the impact of differentiation on students' learning identity and resilience makes this study relevant for the future.

RECOMMENDATION

Based on these observations, further research is recommended to explore the long-term impact of integrating differentiated learning with active learning models on the development of students' learning identities, scientific resilience, and performance on standardized assessments. Furthermore, in-depth field studies are needed to assess the effectiveness of implementing differentiation in educational contexts with limited resources, especially in remote and rural schools. Research should also examine the influence of teacher professional training on the appropriateness and consistency of implementing differentiated learning, as well as developing adaptive and sustainable mentoring or training models. On the other hand, the development of evaluation instruments that are able to measure student achievement based on learning styles and involvement in PBL and PjBL is also important for further research. Thus, further research can strengthen the pedagogical and operational basis for implementing differentiation in educational science that is more inclusive and effective.

BIBLIOGRAPHY

Agustina, L. (2023). *Differentiated Learning with Project Based Learning Model in Terms of Student Learning Style*. *1*, 160–166. https://conference.ut.ac.id/index.php/ictl/article/view/1922

Anggraini, F., Oktageri, D., Akbar, M., Waskito, W., & Yustisia, H. (2024). Implementasi Pembelajaran Berbasis Visual, Auditory dan Kinesthetic (VAK) di Pendidikan Kejuruan:

Systematic Literature Review. *Jurnal Ilmiah Edutic : Pendidikan dan Informatika*, *10*(2), 149–159. https://doi.org/10.21107/edutic.v10i2.26228

Astuti, E. A. (2023). Peningkatan Keterampilan Laboratorium Peserta Didik Melalui Pembelajaran Penemuan (Discovery) pada Materi Penyetaraan Reaksi Kimia Kelas X. *Journal for Energetic Youngsters*, *1*(2), 66–78. http://112.78.41.197/ojs3smagaku/index.php/journey/article/view/18

Cuevas, J. (2015). Is Learning Styles-based Instruction Effective? A Comprehensive Analysis of Recent Research on Learning Styles. *Theory and Research in Education*, *13*(3), 308–333. https://doi.org/10.1177/1477878515606621

Fadhila, A., Agusdianita, N., & Desri, D. (2024). Literatur Review: Gaya Belajar Siswa Sekolah Dasar. *Social, Humanities, and Educational Studies (SHES): Conference Series*, *7*(3). https://doi.org/10.20961/shes.v7i3.91550

Fajrin, S., Haetami, A., & Marhadi, M. A. (2020). Identifikasi kesulitan belajar kimia siswa pada materi pokok larutan asam dan basa di kelas XI IPA2 SMA Negeri 1 Wolowa Kabupaten Buton. *Jurnal Pendidikan Kimia FKIP Universitas Halu Oleo*, *5*(1), 27.

Frerejean, J., van Geel, M., Keuning, T., Dolmans, D., van Merriënboer, J. J., & Visscher, A. J. (2021). Ten Steps to 4C/ID: Training Differentiation Skills in A Professional Development Program for Teachers. *Instructional Science*, *49*, 395–418.

Hasanah, S. U. (2019). Studi Komparasi Penerapan Metode Active Learning Model Reading Aloud Dan Metode Konvensional Model Ceramah Dalam Pembelajaran Bahasa Arab Dan Pengaruhnya Terhadap Respon Siswa Kelas V Mi Ma'arif 01 Pahonjean Majenang. *Jurnal Tawadhu*, *3*(1), 804–822.

Holme, T., & Murphy, K. (2012). The ACS Exams Institute undergraduate chemistry anchoring concepts content map I: General Chemistry. *Journal of Chemical Education*, *89*(6), 721–723. https://doi.org/10.1021/ed300050q

Jannah, R., Husniarti, B. S. A., & Anwar, Y. A. S. (2023). Penerapan Pembelajaran Berdiferensiasi untuk Meningkatkan Aktivitas dan Hasil Belajar Kimia Siswa Kelas X Di SMAN 6 Mataram. *Jurnal Asimilasi Pendidikan*, *1*(2), 136–143. https://doi.org/10.61924/jasmin.v1i2.21

Juliani, R., Rahmatsyah, R., Lubis, R. H., Bara, A. S. B., Nasution, B., Khoir, A. I., Febriza, T. R., Lubis, N. S., Syahdila, T., & Andini, K. (2024). Implementasi Pembelajaran Diferensiasi Berbasis Projek dalam Mengakselerasi Kurikulum Merdeka. *SELAPARANG: Jurnal Pengabdian Masyarakat Berkemajuan*, *8*(3), 3006–3014. https://doi.org/10.31764/jpmb.v8i3.25881

Lavania, M., & Nor, F. B. M. (2020). Barriers In Differentiated Instruction: A Systematic Review Of the Literature. *Journal of Critical Reviews*, *7*(6), 293–297. http://dx.doi.org/10.31838/jcr.07.06.51

Maher, A., van Rossum, T., & Morley, D. (2023). Assessing the learning of pupils with special educational needs and disabilities in mainstream school physical education. *British Educational Research Journal*, *49*(1), 110–125. https://doi.org/10.1002/berj.3263

Marantika, J. E., Tomasouw, J., & Wenno, E. C. (2023). Implementasi pembelajaran berdiferensiasi di kelas. *German Für Gesellschaft (J-Gefüge)*, *2*(1), 1–8.

Minarni, M., Erpita, R., Permadi, A., Mahdi, I., & Samitra, D. (2024). Pembelajaran Berdiferensiasi Gaya Belajar pada Asam Basa. *JURNAL PERSPEKTIF PENDIDIKAN*, *18*(2), 223–231. https://doi.org/10.31540/jpp.v18i2.3310

Muhab, S., Rini, T. D. S., Erdawati, E., & Irwanto, I. (2024). Evaluation of Differentiated Learning in Chemistry by Using the CIPP Evaluation Model. *Jurnal Penelitian Pendidikan IPA*, *10*(2), 923–939. https://doi.org/10.29303/jppipa.v10i2.5985

Nestiyarum, Y., & Widjajanti, E. (2023). Differentiated Project Based Learning to Improve Collaboration Skills and Cognitive Learning Outcomes of High School Students on Colloidal System Material. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 11441–11447. https://doi.org/10.29303/jppipa.v9i12.4867

Ojelade, I., Apochi, M., Aregbesola, B., & Ejedegba, O. (2024). *Effects of Differentiated Instruction on Chemistry Students' Achievement and Retention in Secondary Schools, Abuja, Nigeria*. *1*(8).

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., & Brennan, S. E. (2021). The PRISMA 2020 Statement: An Updated Guideline For Reporting Systematic Reviews. *Bmj*, *372*. https://doi.org/10.1136/bmj.n71

Prima, S. S., & Abdurahman, A. (2024). The Influence of Discovery Learning Methods and Reading Interest on the Writing Skills of Explanatory Texts. *Journal of Languages and Language Teaching*, *12*(3), 1155–1173. https://dx.doi.org/10.33394/jollt.v12i3.11599

Raehani, S. A., Istiyarini, L., & Baqiyatusshalihah, B. (2023). Penerapan Model Pembelajaran Berbasis Masalah (Problem Based Learning) untuk Meningkatkan Minat Belajar Kimia Siswa Kelas X. 1 di SMA Negeri 4 Mataram. *Jurnal Literasi Dan Pembelajaran Indonesia*, *3*(2), 169–174. https://jurnalfkip.samawa-university.ac.id/JLPI/article/view/548

Rohim, M. A. M., Theis, R., & Anwar, K. (2024). Pengaruh Pembelajaran Diferensiasi Berbasis Masalah Berdasarkan Kesiapan Belajar Siswa terhadap Kemampuan Pemecahan Masalah Matematis Kelas VIII SMP. *Jurnal Pendidikan Mipa*, *14*(2), 388–396. https://doi.org/10.37630/jpm.v14i2.1549

Safitri, R. F., & Haryani, S. (2025). Peningkatan Kemampuan Berpikir Kritis Siswa pada Materi Stoikiometri Melalui Penerapan Pembelajaran Berdiferensiasi Terintegrasi Problem Based Learning (PBL) dalam Kurikulum Merdeka. *Jurnal Inovasi Pendidikan Kimia*, *19*(1), 41–50. https://doi.org/10.15294/574tkt21

Salar, R., & Turgut, U. (2021). Effect of Differentiated Instruction and 5E Learning Cycle on Academic Achievement and Self-Efficacy of Students in Physics Lesson. *Science Education International*, *32*(1), 4–13. https://www.icaseonline.net/journal/index.php/sei/article/view/255

Samura, A. O. (2019). Kemampuan berpikir kritis dan kreatif matematis melalui pembelajaran berbasis masalah. *MES: Journal of Mathematics Education and Science*, *5*(1), 20–28. https://core.ac.uk/download/pdf/270240846.pdf

Sedeṅo, M. M., Villamor, G. T., & Masuhay, E. P. (2021). Differentiated Instruction in General Chemistry. *International Journal of Innovative Science and Research Technology*, *6*(4), 323–330. https://www.researchgate.net/profile/Edilmar-Masuhay/publication/353751480_Differentiated_Instruction_in_General_Chemistry/links/610e370f1ca20f6f860772c7/Differentiated-Instruction-in-General-Chemistry.pdf

Subban, P. (2006). Differentiated instruction: A research basis. *International Education Journal*, *7*(7), 935–947.

Sulistiawati, S., Afrida, A., & Miharti, I. (2025). Pengaruh Model Pembelajaran Project Based Learning (PjBL) dengan Pendekatan Berdiferensiasi untuk Meningkatkan Kemampuan Berpikir Kritis Siswa pada Materi Asam Basa. *Indonesian Research Journal on Education*, *5*(2), 1058–1067. https://doi.org/10.31004/irje.v5i2.2433

Suryanti, M., Choirunnisa, N. L., & Diningrat, S. W. M. (2025). Penyusunan Desain Pembelajaran Berdiferensiasi Sebagai Implementasi Kurikulum Merdeka di Sekolah Indonesia Luar Negeri. *Jurnal Publikasi Pendidikan*, *15*(1), 1–9. https://doi.org/10.26858/publikan.v15i1.65919

Tomlinson, C. A. (2014). *The differentiated classroom: Responding to the needs of all learners*. Ascd.

Wahyuni, E., Fitria, Y., & Hidayati, A. (2023). Implementation of Student Learning Independence in Ethnoscience-Oriented Force Topics Through Problem Based Learning (PBL) Learning Model. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 11414–11421. https://doi.org/10.29303/jppipa.v10i4.6167

Wardani, S. F., Yamtinah, S., Mulyani, B., Susilowati, E., Ulfa, M., Masykuri, M., & Shidiq, A. S. (2024). Differentiated Learning: Analysis of Students' Chemical Literacy on Chemical Bonding Material through Culturally Responsive Teaching Approach Integrated with Ethnochemistry. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 1747–1759. https://doi.org/10.29303/jppipa.v10i4.6167