Journal of Current Studies in SDGs
Homepage : https://journal.i-ros.org/index.php/JOCSIS
Email : jocsis@i-ros.org

e-ISSN 3089-7564
Vol.2, No.2, June 2026

Integrating Culturally Responsive Teaching and Differentiated Learning to Promote Critical Thinking in Chemistry Learning toward Sustainable Development Goal 4

Fitriyuni Miralda Siregar*, Yuli Rahmawati, Achmad Ridwan

Universitas Negeri Jakarta, Jakarta, Indonesia

Check for updates · Open Access · CC BY

DOI : https://doi.org/10.63230/jocsis.2.2.177

Sections Info

Article history:
Submitted: May 20, 2026
Final Revised: June 4, 2026
Accepted: June 10, 2026
First Available Online: June 26, 2026
Publication Date: June 27, 2026

Keywords:
Chemistry Learning;
Critical Thinking Skills;
Culturally Responsive Pedagogy;
Culturally Responsive Teaching (CRT);
Differentiated Learning;
Inclusive Learning Environment.

ABSTRACT

Objective: *To combine Culturally Responsive Teaching (CRT) and differentiated learning in chemistry instruction to increase student engagement and improve students' critical thinking skills.* ***Method:*** *Qualitative research conducted at MA Pembangunan UIN Jakarta involving 32 students. The learning model was implemented in chemistry topics of hydrolysis and acid-base titration. Data were collected through interviews, observations, and reflective journals.* ***Results:*** *The implementation of CRT-integrated differentiated learning improved students' critical thinking skills. Students were able to connect chemical concepts with relevant real-life experiences and cultural contexts. The approach also promoted active participation, collaboration, appreciation of cultural diversity, and an inclusive learning environment.* ***Novelty:*** *Proposing an integrated instructional framework that combines Culturally Responsive Teaching (CRT) and differentiated learning to foster students' critical thinking in chemistry education while advancing Sustainable Development Goal (SDG) 4: Quality Education. The framework promotes inclusive, equitable, and culturally relevant learning by accommodating diverse student backgrounds and learning needs, thereby supporting both conceptual understanding and higher-order thinking skills.*

INTRODUCTION

The diversity of students in learning requires attention to their levels of achievement, backgrounds, language abilities, particular educational needs (Nusser & Gehrer, 2020; Gusteti & Neviyarni, 2022; Tomlinson, 2001), cognitive development, initial abilities, learning styles, motivation, and more (Estari, 2020). This diversity is a valuable asset. Diverse classrooms enhance learning by facilitating opportunities for students to learn from each other about their different cultures, experiences, and perspectives (Forbes & Lord, 2024). Given this unique diversity, teachers can design learning by differentiating content, processes, teaching outcomes, or learning environments according to students' readiness, passion, and profile (Hiruy, & Melesse, 2022). As facilitators in the classroom, teachers can meet students' diverse needs and empower them individually in the learning process (Strogilos et al., 2023) while providing authentic, realistic, and genuine experiences (Güth & van Vorst, 2024). They do this by detailing what needs to be learned (Nsabayezu et al., 2022; Üce & Ceyhan, 2019). Designing learning for different competency levels is considered a vital method to enable all students to participate in the class and develop competencies according to their levels of achievement. One approach that can support such learning is differentiated instruction (Melesse & Belay, 2022). Differentiated instruction also accommodates all student differences in readiness, interest, and learning profiles (Pozas & Letzel-Alt, 2023; Valiandes & Neophytou, 2018). Research shows that students' learning abilities are higher in classrooms implementing differentiated instruction (Haelermans, 2022), and this approach positively impacts critical, creative, and innovative thinking abilities (Avandra & Desyandri, 2023; Latifah et al., 2023), especially in chemistry subjects.

Chemistry learning in classrooms faces issues, particularly when the concepts taught by teachers do not align with the student's everyday characteristics and situations. This misalignment can hinder the development of their critical thinking (Habig et al., 2018). Critical thinking involves analyzing, evaluating, and meticulously dictating information (Tiruneh et al., 2018). Differentiated instruction will stimulate students' critical thinking skills, aiding their success in learning and scientific careers (Garvin-Hudson & Jackson, 2018). Various studies have shown differentiated instruction to be a method that can address student diversity. Still, unfortunately, it has not been adequately tailored for students with diverse cultural and linguistic backgrounds (Santamaria, 2009), particularly in Indonesia. As a country with rich cultural diversity, Indonesia has yet to widely explore its cultural diversity in chemistry learning to create meaningful learning experiences (Rahmawati et al., 2019). Previous studies show that school chemistry education has yet to connect with students' cultural backgrounds optimally (Andina et al., 2017; Tan, 2017). Culturally Responsive Teaching (CRT) links cultural diversity with education to enhance the quality and success of the learning process (Heitner & Jennings, 2016). Integrating elements of Indonesian culture into chemistry education can deepen understanding and embed local values. CRT stimulates students' awareness of the role of chemistry in daily life, influencing their understanding of their culture (Rahmawati & Ridwan, 2017). CRT acknowledges and appreciates Indonesia's cultural diversity within the education system, creating an environment that celebrates and respects cultural heritage (Arfa & Lasaiba, 2022). Teachers must understand their students' cultures, attitudes, behaviors, and beliefs to provide culturally responsive instruction and represent all diverse groups, reflecting their realities (Rodríguez, 2014). Given the abovementioned issues, an approach is needed to develop students' critical thinking skills in chemistry learning. This approach integrates CRT with differentiated instruction, designed to provide equitable treatment to all students and offer differentiation that meets their individual learning needs.

Therefore, this study investigates the integration of Culturally Responsive Teaching (CRT) into differentiated learning in chemistry education to develop students' critical thinking skills. Specifically, this study explores how the integrated instructional model creates culturally relevant learning experiences, accommodates diverse student characteristics, and supports the development of critical thinking. The findings are expected to provide an instructional framework that contributes to the implementation of SDG 4 (Quality Education) by promoting inclusive, equitable, and high-quality chemistry learning.

Integrated differentiated instruction model with Culturally Responsive Teaching (CRT)

Differentiated instruction model

Differentiated teaching is an inquiry-based, student-focused, and activity-based pedagogical approach. These approaches allow teachers to plan and customize their teaching methods to accommodate each student's learning needs (Strogilos et al., 2023). To address student diversity, differentiated teaching can balance the academic content and the student's characteristics (knowledge background, passion, readiness, and learning profile) (Melesse & Belay, 2022). According to Tomlinson (2001), teachers use differentiated teaching when they plan various approaches related to the content that needs to be learned, how students will know it, and how they will demonstrate what they have learned. Differentiated instruction in learning results in approaches to the elements such as content (input), what students learn; process, how students understand the information and ideas offered; and product (output), how students apply and display what they have understood (Tomlinson, 2001).

Culturally Responsive Teaching (CRT) model

Geneva Gay (2000) defines Culturally Responsive Teaching (CRT) as maximizing students' ability to learn and culturally appropriate academic and psychosocial development. CRT involves a student's knowledge of their culture, pre-existing experiences that are their strengths, and learning style to make learning more effective and relevant to the student's life (Gay, 2000). According to Ladson-Billings, CRT practices aim to improve students' academic achievement and strengthen their cultural identity. Teachers who implement this type of teaching help students meet three criteria: academic success, cultural competence, and critical awareness (Ladson-Billings, 1995). The development design of the Culturally Responsive Teaching approach that can be used in mathematics and science learning is proposed by Hernandez et al. (2013), which consists of content integration, facilitating knowledge construction, prejudice reduction, social justice, and academic development. This design can assist teachers in developing learning, especially in science. The implementation of CRT in classrooms positively impacts learning progress. Quantitative findings by Singh and Akar (2021) show that teachers who implement CRT in their classes have a high level of readiness and skills in managing culturally diverse classrooms, while qualitative findings present deep confidence among teachers regarding their characteristics and personal attitudes towards cultural diversity as a strength in their teaching (Dolapcioglu & Doğanay, 2022).

Integrated differentiated instruction model with Culturally Responsive Teaching (CRT)

The integrated, differentiated instruction approach with Culturally Responsive Teaching (CRT) consists of five main steps: self and cultural exploration, factual integration, idea sharing, critical analysis, and character validation. These steps can be applied as shown in Figure 1, which illustrates the steps corresponding to the students' characteristics and needs.

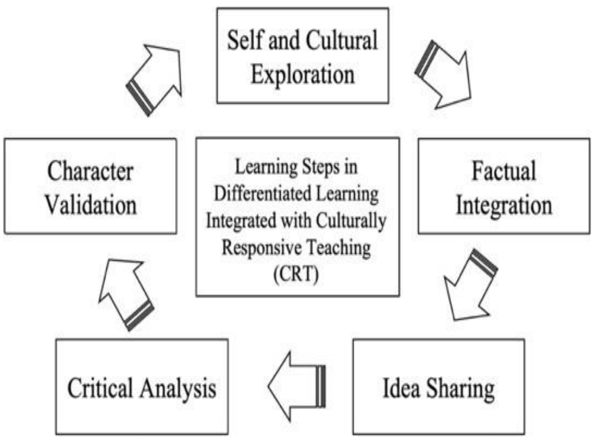

Figure 1. Learning steps in differentiated learning integrated with Culturally Responsive Teaching (CRT)

These five steps form a unified process that meets the needs and adaptations to the diversity of students in the classroom. First, the self and cultural exploration step encourages students to understand and appreciate their identities and cultures within the learning context. Factual integration emphasizes the importance of including information and examples from various cultures in learning, allowing students to feel connected to the subject. Third, idea sharing teaches students to exchange ideas and experiences, enrich classroom discussions, and value different perspectives. Fourth, critical analysis encourages students to evaluate information critically, question assumptions, and develop analytical thinking. The final step, character validation, recognizes and appreciates the moral, ethical, and personal qualities students demonstrate during the learning process. These five steps aim to create an inclusive, empowering, and diversity-respecting learning environment while strengthening the connection between classroom learning and the students' cultural, social, and personal realities. All these steps can be repeated to achieve the learning targets that have been collaboratively formulated.

Critical thinking skills

Critical thinking is an intellectually disciplined process that requires the ability to actively and skillfully evaluate data collected from experiences through communication, observation, perception, practice, analysis, synthesis, reflection, logic, and reasoning. The Critical Thinking Skills Rubric (CTR) developed by Dolapcioglu and Doğanay (2022) used in this study includes five skill indicators: understanding, comparing, and evaluating solutions, reaching and proving the correct solution, suggesting new solutions, and reflection. Critical thinking skill indicators consist of the following criteria: (1) identifying changes in the color of red and blue litmus indicators in various salt solutions through problem understanding, (2) comparing various pieces of information related to the application of ion equilibrium in salt solutions and providing solutions based on the evaluations conducted. Indicator (3) provides practical solutions related to ion equilibrium in salt solutions and acid-base properties. Indicator (4) analyzing the procedure for acid-base titration, including the endpoint and equivalence point of acid-base titration, creating titration curves with appropriate indicators, determining the concentration of the titrant or the substance being titrated, and providing solutions to real-life cases and evidence. Indicator (5) provides solutions for real-life applications regarding the pH of salt solutions. Indicator (6) reflects on the experimental results to predict the pH of salt solutions using litmus paper/indicators.

RESEARCH METHOD

Research design

The research methodology used in this study is qualitative. A qualitative method was chosen because this study focuses on developing students' critical thinking skills through Differentiated Learning integrated with Culturally Responsive Teaching on hydrolysis and acid-base titration materials. In qualitative research, the researcher needs data that can be used to describe the state or phenomena as they are. Data collection in this study is based on observations made during the research (Figure 2), students' reflective journals, teachers' journals, and intensive interviews with the XI MIA 1 class at MA Pembangunan UIN Jakarta.

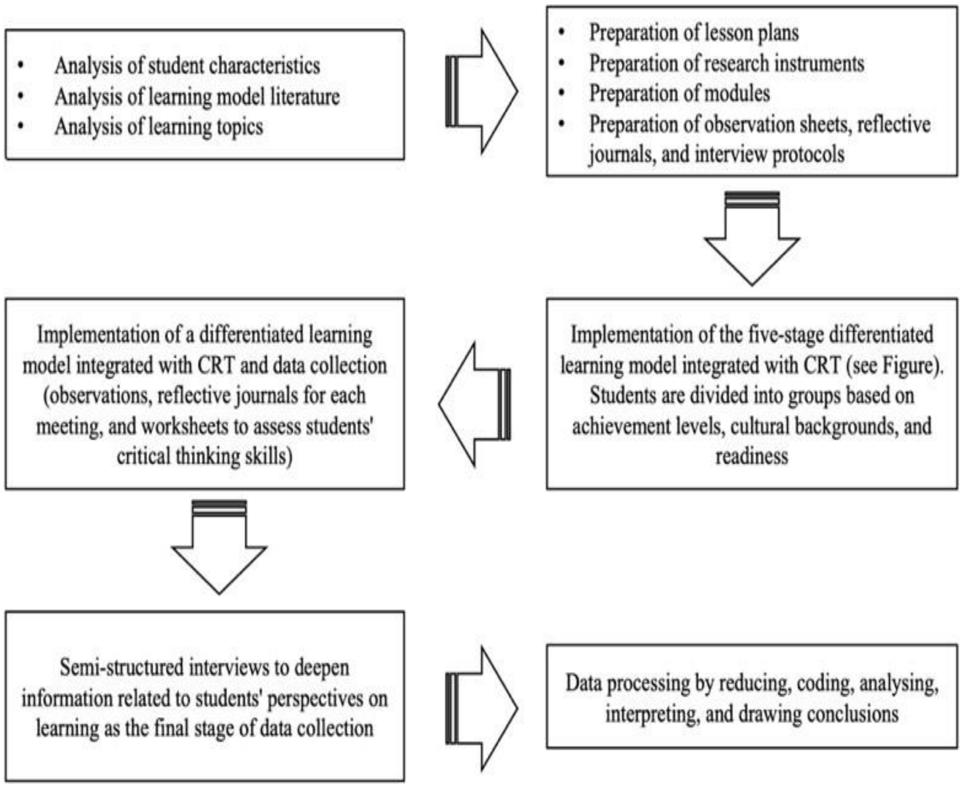

Figure 2. Research design

Data collection

Qualitative data were obtained through classroom observations, student reflective journals, and semi-structured student interviews. In conducting classroom observations of teacher-student and student-student interactions, the researcher was assisted by four observers who were teachers from partner schools. This method helps provide an overall picture of implementing the differentiated learning model integrated with CRT. To uncover individual student learning experiences, they were directed to answer questions in reflective journals designed to explore and develop students' critical thinking skills. Here are examples of reflective journal questions:

> *What are your thoughts on today's lesson? What challenges did you encounter during the learning process?Evaluate your performance in today's lesson!*

Semi-structured interviews were conducted to explore students' learning experiences and the development of their critical thinking skills. Here are examples of interview questions:

> *Hi, how are you? Do you enjoy studying chemistry? Do you feel you understand the material better when it is related to everyday life? Can you explain the hydrolysis process that occurs in Betawi pickles? After this learning process, do you feel more confident in expressing opinions and critical thinking? What strengths have you gained from this learning?*

A critical thinking skills test was also conducted to map the development of students' critical thinking abilities. An example question is as follows:

> *"In the food industry, preservatives such as sodium benzoate are often added to extend the shelf life of food products. However, most cake sellers do not use this method because of the increased production costs of purchasing these preservatives. Explain the effect of adding sodium benzoate to Dongkal cake on the food's pH after adding sodium benzoate, connecting it with the acidic and basic properties of the resulting reaction!"*

Trust and data analysis

Data analysis uses a constructivist grounded theory approach. Data were processed using interview transcripts, coding the data, categories into themes and subthemes, and narratives of the findings. Implementing the integrated and differentiated CRT learning model uses this method to produce a database and its implications in involving students in learning. The quality of data produced during research and data accountability is carried out epistemologically, where researchers apply credibility criteria. According to Gubda and Lincoln (1989), cited in Enworo (2023), qualitative research can be done through credibility. The credibility of the data includes prolonged engagement, persistent observation, progressive subjectivity, and member checking. Prolonged engagement in this research is carried out to study, understand, and observe students' environment, learning styles, and attitudes before and during learning. Persistent Observation was conducted to deepen information related to the development of critical thinking skills in students and the implementation of CRT-integrated differentiated learning. Progressive subjectivity is achieved by continuously monitoring learning activities and is associated with the development of students' critical thinking skills. Member checking determines whether the data from the observation of the development of critical thinking skills with differentiated learning integrated with culturally responsive teaching obtained during the research process, data processing, and analysis are correct and appropriate.

RESULTS AND DISCUSSION

Results

Pedagogical strategies to engage students in Culturally Responsive Teaching (CRT) integrated differentiated learning

A better understanding of students' cultural backgrounds supports differentiated learning, where teachers can create more effective and relevant learning strategies (Sedeňo et al., 2021). By linking students' cultural identity with the learning materials, teachers can help them find relevance and real-life applications of chemistry concepts in their daily lives. As a country with diverse cultures, Indonesia has yet to explore Indonesia's cultural diversity in chemistry learning widely to create meaningful learning experiences (Rahmawati et al., 2019).

Learning methods

Differentiated learning by integrating CRT, conducted in this research, applies various learning methods tailored to diverse students' needs. Examples of techniques used are think-tac-toe, tiered lesson, RAFT, jigsaw, pro-con debate, and others. This is proven by Observer 4's notes, where it is stated that students actively solve questions submitted through a game in groups. The solution in this game is reviewed with other groups regarding the correct answer per the information learned (Observer's Note 4, May 13, 2024). Student 31's reflective journal also stated that he could understand after further explanation (Reflective journal, PD-31, May 13, 2024). Sixteen students also agreed that the think-tac-toe learning was enjoyable; I rate it 10/10 because the material was so easy to learn that I found it easy to answer the quiz given (Reflective Journal, PD-16, May 13, 2024).

Differentiated learning integrated Culturally Responsive Teaching (CRT)

Self and cultural exploration is the process of understanding oneself about the individual's readiness, interests, learning profile, and cultural background. Through self- and artistic exploration, individuals can gain information, ideas, and skills about their characteristics and needs, increase their sense of identity and self-esteem, and appreciate cultural diversity in society. This is based on research by Rahmian et al. (2024), where students' identities, including their culture, are respected, and it will support positive collaboration and progress towards new ideas. For example, student PD-1 admitted, "I am a feeling person, so in learning, my feelings dominate, and that includes anything" (Self-Identification File, PD-1, May 6, 2024). This is the initial information about students' learning readiness. Another thing was expressed by student PD-10, where he stated, "It is more fun to learn in groups" (Self Identification File, PD-10, May 6, 2024). Corroborated by student PD-18: "Grouping makes it easier for me to understand the material because I can exchange knowledge" (Self Identification File, PD-18, May 6, 2024). With grouping and using the integrated, differentiated learning model in the first meeting, the results obtained were information from PD-5, where he wrote, "I can receive chemistry material relatively quickly" (Self Identification File, PD-5 May 6, 2024).

Factual integration in learning refers to the use of concrete data or facts. It incorporates empirical information or actual events into learning activities and class discussions to support understanding of the concept or topic being taught. As van Riesen et al. stated, students with good prior knowledge perform best in the lesson [36]. Learning steps are formed into five groups according to student readiness in the factual integration stage. Each group sought answers to the problems (Observer 1 note, May 17, 2024). PD-2 students feel the benefits when chemistry is connected to everyday life, namely, "I understand chemistry better, which is connected to everyday life during practicum. I feel that I can solve problems in everyday life, such as adding preservatives in the form of salt to certain foods" (Interview PD-2, May 22, 2024). Studying chemistry in the way that students like makes students recognize their strengths. For example, as in the interview of PD-29: "The strengths that I get by studying chemistry with contextual materials are first confidence, the second is our criticism of the material, the third is brainstorming for us (Interview PD-29, May 31, 2024). Corroborated with information from student interview PD-3, "By being associated with everyday life, I become more interested in chemistry lessons" (Interview PD-3, May 8, 2024).

Idea sharing refers to the process by which students and teachers share diverse ideas, views, or ideas in an inclusive and culturally responsive learning context. Group students discuss with each other and are active" (Observer 4's note, May 31, 2024). In interview PD-29, information was obtained that "Chemistry learning becomes varied ma'am because groups are made per material, later we get one material point (idea) and share with other groups and the same" (Interview PD-29, May 31, 2024). According to the research results of Zielhius et al. (2024), students will benefit from active involvement in the classroom. By reviewing and sharing these ideas, students can expand their understanding of the topic being studied. Sharing ideas enriches individual knowledge and allows students to see different perspectives and gain new insights from their peers.

The problem-solving process in this lesson involves various stages, starting from understanding the problem, analyzing available information, formulating hypotheses, and testing and evaluating results. Through this exercise, students can hone their critical and applicative thinking skills in a natural context. Students are encouraged to express their opinions critically on the problem or ideas offered in class discussions or presentation sessions. They are invited to receive information passively and analyze, evaluate, and provide feedback based on their critical thinking. During learning, after exchanging or sharing ideas, students can carefully evaluate the information presented (Observer's Note 3, May 13, 2024). Another fact was that students could link various opinions in their group to produce an exact and accurate answer before expressing it to the teacher (Observer's Note 4, May 13, 2024). This is to the research results of Moghadam et al., where learning based on critical thinking allows students to form good ideas regarding things around them, even influencing the classroom climate, engagement, and cooperation for the better (Moghadam et al., 2023). By encouraging students to think critically, teachers help them develop more profound and reflective thinking skills.

Learners are asked to identify their strengths and expertise. This involves self-reflection, in which they consider the skills, knowledge, and competencies they have mastered. After listing these strengths, students match them to their learning targets. These targets include qualities in various aspects such as content (information, ideas, concepts, materials) and how they can utilize these strengths to achieve the set goals. Some of the strengths obtained by students after learning chemistry with the application of CRT integrated differentiated learning model are very positive and varied; for example, student PD-32 stated, "I have to be careful in pouring the solution because, in the previous practicum, I was not careful in pouring the solution" (Reflective Journal, PD-32, May 31, 2024). He found that being careful is a quality target he must fulfill to become a better person. As expressed by student PD-1: "I worked a lot in today's practicum but was less active in asking questions; in the next chemistry meeting, I will try to be better" (Reflective Journal, PD-1, May 31, 2024). Another strength that students found: "I am better than the previous meeting because my strength is critical" (Reflective Journal, PD-29, May 31, 2024). This is based on research by Ozcan (2016), which states that internal motivation has a high predictive power in problem-solving in learning. Making a list of strengths helps students focus on self-development and achieving targets effectively and efficiently.

Results of critical thinking skills with Culturally Responsive Teaching (CRT) integrated differentiated learning model

Critical thinking skills in implementing the Culturally Responsive Teaching (CRT) Integrated Differentiated Learning Model were tested through an essay test of 6 questions, validated by five expert validators. As many as six questions were obtained. These indicators are also given in the observation sheet during the implementation of learning. In the interview process, students were also asked critical thinking skills questions to determine how much the CRT-integrated differentiated learning model improved students' critical thinking skills.

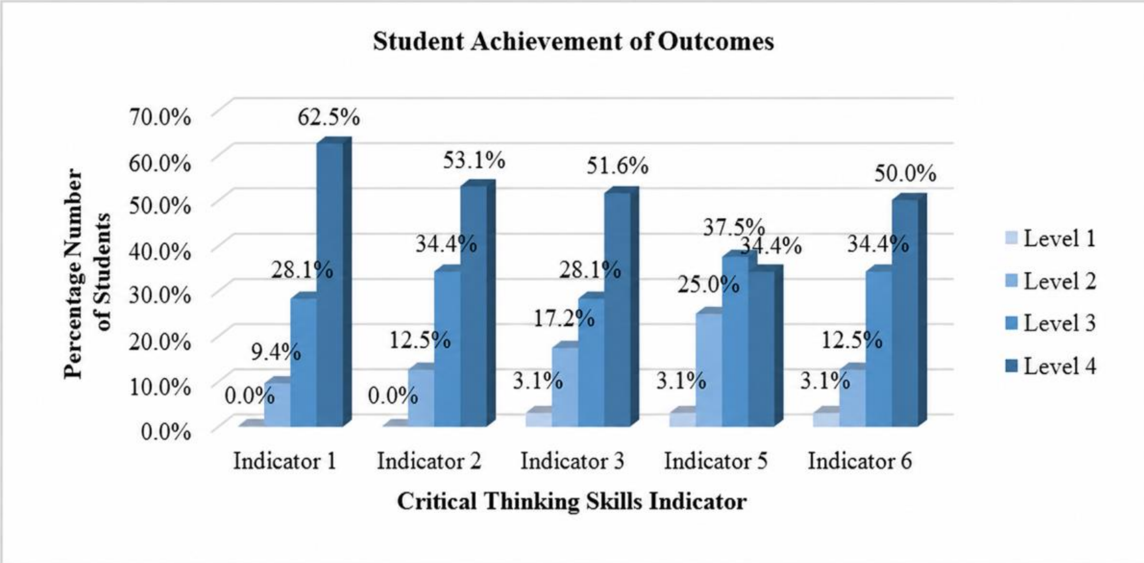

Figure 4. Student achievement of outcomes

The histogram in Figure 4, shows the achievement of students' results in carrying out exams with indicators one to five on critical thinking skills, divided into four levels: Level 1, Level 2, Level 3, and Level 4. In Indicator 1, most students are at Level 4 (62.5%), indicating they can demonstrate their ability in Indicator 1. In Indicator 2, most students were at Level 4, which was 53.1%, while in Indicator 3, which contained two skill indicators, Level 4 was achieved by 51.6% of students. In Indicator 4, 37.5% of students obtained Level 4 skills, and in Indicator 5, 50% obtained Level 4. This is to findings from Dolapcioglu and Doğanay (2022), where the application of authentic learning principles, such as giving students time to think individually and involving them in discussions with peers to compare solutions and provide evidence for their thinking can support the development of deeper understanding. Depth in the learning. This histogram shows that most students have good to excellent critical thinking skills (Level 3 and Level 4) in all indicators measured. Indicator 1 shows the highest percentage for Level 4, while Indicators 3 and 4 have a more even distribution among the other skill levels.

Discussion

The findings demonstrate that integrating Culturally Responsive Teaching (CRT) with differentiated learning effectively enhanced students' critical thinking skills in chemistry learning. The predominance of students achieving Level 3 and Level 4 across all critical thinking indicators suggests that the instructional model successfully supported higher-order thinking through culturally meaningful and differentiated learning experiences. These findings indicate that students were not only able to understand chemistry concepts but also analyze, evaluate, and apply them in authentic situations.

The highest achievement was observed in Indicator 1, where 62.5% of students reached Level 4. This result suggests that connecting chemistry concepts with students' cultural experiences and prior knowledge facilitated a stronger conceptual foundation before engaging in more complex reasoning. According to constructivist learning theory, meaningful learning occurs when new knowledge is connected to learners' existing experiences, allowing students to construct deeper conceptual understanding. The self- and cultural exploration stage provided opportunities for students to activate their background knowledge, making chemistry concepts more relevant and easier to understand.

The consistently high performance in Indicators 2 (53.1%), 3 (51.6%), and 6 (50.0%) further demonstrates that differentiated learning integrated with CRT supported students in comparing information, evaluating evidence, proposing solutions, and reflecting on their learning. These findings are consistent with Tomlinson (2001), who argues that differentiated instruction accommodates students' readiness, interests, and learning profiles, enabling learners with diverse characteristics to achieve meaningful learning outcomes. At the same time, integrating students' cultural backgrounds into chemistry learning provided authentic contexts that encouraged critical analysis rather than rote memorization.

The relatively lower percentage of students achieving Level 4 in Indicator 5 (37.5%) suggests that solving complex real-life chemistry problems remains more challenging than understanding or analyzing concepts. This indicator required students to integrate conceptual knowledge, scientific reasoning, and contextual problem-solving simultaneously. Nevertheless, the relatively high proportion of students achieving Level 3 indicates that most students had already developed adequate analytical abilities and were progressing toward advanced critical thinking. This finding suggests that contextual chemistry problems require continuous exposure and repeated practice to strengthen students' ability to transfer scientific knowledge into authentic situations.

These findings also demonstrate the complementary relationship between Culturally Responsive Teaching and differentiated learning. While differentiated instruction accommodates differences in students' readiness, learning profiles, and interests, CRT enriches learning by connecting chemistry concepts with students' cultural identities and everyday experiences. The integration of both approaches created an inclusive learning environment where students actively participated in discussion, exchanged ideas, evaluated different perspectives, and reflected on their learning processes. Such classroom interactions are essential for developing critical thinking because students are required to justify their reasoning, evaluate evidence, and consider multiple viewpoints.

Furthermore, the implementation of various instructional strategies including think–tac–toe, RAFT, jigsaw, tiered activities, collaborative discussion, and reflective journals provided multiple pathways for students to construct knowledge according to their individual learning characteristics. These learning experiences encouraged active participation, collaboration, and self-reflection, which are fundamental components of higher-order thinking and student-centered learning. The findings therefore support previous studies reporting that authentic, collaborative, and culturally relevant learning environments significantly contribute to students' critical thinking development.

From the perspective of the Sustainable Development Goals, this study contributes directly to SDG 4 (Quality Education) by demonstrating that integrating CRT with differentiated learning promotes inclusive, equitable, and high-quality chemistry education. The instructional model respects students' cultural diversity while simultaneously accommodating different learning needs, thereby providing equitable learning opportunities for all students. Rather than applying a uniform instructional approach, the model recognizes diversity as an educational resource that enriches learning experiences and supports the development of essential twenty-first-century competencies, particularly critical thinking. Therefore, the integration of CRT and differentiated learning represents an effective pedagogical strategy for advancing SDG 4 through culturally relevant, inclusive, and student-centered science education.

CONCLUSION

Fundamental Finding: The integration of Differentiated Learning and Culturally Responsive Teaching (CRT) effectively enhanced students' critical thinking skills while promoting culturally relevant, meaningful, and inclusive learning experiences. The five instructional stages self- and cultural exploration, factual integration, sharing ideas, critical analysis, and character validation supported both students' intellectual and personal development. **Implication:** The findings demonstrate that integrating students' cultural backgrounds into differentiated instruction contributes to the achievement of Sustainable Development Goal 4 (Quality Education) by promoting inclusive, equitable, and learner-centered chemistry education. This integrated approach enhances students' engagement, confidence, participation, and higher-order thinking skills while accommodating diverse learning needs, cultural identities, and learning profiles. The proposed instructional framework provides educators with a practical strategy for creating culturally responsive and inclusive classrooms that foster critical thinking and support the development of essential twenty-first-century competencies. **Limitation:** Your conclusion should be the best part of your paper. **Future Research:** Future studies should examine the effectiveness of CRT-integrated differentiated learning across different educational levels, disciplines, and cultural settings. Researchers may also investigate its impact on other 21st-century competencies, such as creativity, collaboration, communication, problem-solving, and intercultural competence, using quantitative or mixed-methods approaches.

AUTHOR CONTRIBUTIONS

Fitriyuni Miralda Siregar contributed to the conceptualization of the study, research design, methodology development, data collection, formal analysis, data interpretation, visualization, and preparation of the original manuscript draft. **Yuli Rahmawati** contributed to the conceptual framework, supervision, validation, manuscript review and editing, and provided academic guidance throughout the research process. **Achmad Ridwan** contributed to the research methodology, validation, data interpretation, manuscript review and editing, and supervision. All authors have read, reviewed, and approved the final version of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors state that no financial or personal conflicts of interest exist that may have affected the content or findings of this research.

STATEMENT ON THE USE OF AI OR DIGITAL TOOLS IN WRITING

The authors declare that no artificial intelligence (AI) tools or other digital writing assistants were used in the preparation, analysis, or writing of this manuscript. All stages of the research process, including data analysis, interpretation, and manuscript writing, were conducted solely by the authors. The authors take full responsibility for the originality, accuracy, and integrity of the content presented in this article.

REFERENCES

Andina, R. E., Ridwan, A., & Rahmawati, Y. (2017). Analisis model mental siswa pada materi hidrolisis garam di Klaten. *Jurnal Riset Pendidikan Kimia*, *7*(2), 144–152. https://doi.org/10.21009/JRPK.072.08

Arfa, A. M., & Lasaiba, M. A. (2022). Pendidikan multikultural dan implementasinya di dunia pendidikan. *Geoforum, 1*(2), 36–49. https://doi.org/10.30598/geoforumvol1iss2pp36-49

Avandra, R., & Desyandri. (2023). Implementasi pembelajaran berdiferensiasi terhadap keterampilan berpikir kritis siswa pada pembelajaran IPA kelas VI SD. *Didaktik: Jurnal Ilmiah PGSD STKIP Subang, 8*(2), 2944–2960. https://doi.org/10.36989/didaktik.v8i2.618

Dolapcioglu, S., & Doğanay, A. (2022). Development of critical thinking in mathematics classes via authentic learning: An action research. *International Journal of Mathematical Education in Science and Technology, 53*(6), 1363–1386. https://doi.org/10.1080/0020739X.2020.1819573

Enworo, O. C. (2023). Application of Guba and Lincoln's parallel criteria to assess trustworthiness of qualitative research on indigenous social protection systems. *Qualitative Research Journal, 23*(4), 372–384. https://doi.org/10.1108/QRJ-08-2022-0116

Estari, A. W. (2020). Pentingnya memahami karakteristik peserta didik dalam proses pembelajaran. *Social, Humanities, and Educational Studies (SHEs): Conference Series, 3*, 1439–1444. https://jurnal.uns.ac.id/SHES/article/view/56953

Forbes, M. H., & Lord, S. M. (2024). Celebrating and leveraging classroom geographic and cultural diversity to enhance student learning. *Education Sciences, 14*(3), Article 287. https://doi.org/10.3390/educsci14030287

Garvin-Hudson, B., & Jackson, T. O. (2018). A case for culturally relevant science education in the summer for African American youth. *International Journal of Qualitative Studies in Education, 31*(8), 708–725. https://doi.org/10.1080/09518398.2018.1478156

Gay, G. (2000). *Culturally responsive teaching: Theory, research, and practice*. Teachers College Press.

Gusteti, M. U., & Neviyarni, N. (2022). Pembelajaran berdiferensiasi pada pembelajaran matematika di Kurikulum Merdeka. *Jurnal Lebesgue: Jurnal Ilmiah Pendidikan Matematika, Matematika dan Statistika, 3*(3), 636–646. https://doi.org/10.46306/lb.v3i3.180

Güth, F., & van Vorst, H. (2024). To choose or not to choose? Effects of choice in authentic context-based learning environments. *Educational Psychology Review*. https://doi.org/10.1007/s10212-024-00798-6

Habig, S., Blankenburg, J., van Vorst, H., Fechner, S., Parchmann, I., & Sumfleth, E. (2018). Context characteristics and their effects on students' situational interest in chemistry. *International Journal of Science Education, 40*(10), 1154–1175. https://doi.org/10.1080/09500693.2018.1470349

Haelermans, C. (2022). The effects of group differentiation by students' learning strategies. *Instructional Science, 50*(2), 223–250. https://doi.org/10.1007/s11251-021-09575-0

Heitner, K. L., & Jennings, M. (2016). Culturally responsive teaching knowledge and practices of online faculty. *Online Learning Journal, 20*(4), 54–78. https://doi.org/10.24059/olj.v20i4.1043

Hernandez, C. M., Morales, A. R., & Shroyer, M. G. (2013). The development of a model of culturally responsive science and mathematics teaching. *Cultural Studies of Science Education, 8*(4), 803–820. https://doi.org/10.1007/s11422-013-9544-1

Hiruy, A., & Melesse, S. (2022). Examining theory-practice gap in implementing Differentiated Instruction (DI) in the Ethiopian TVET system: The case of TVET colleges in Bahir Dar City. *Cogent Education, 9*(1). https://doi.org/10.1080/2331186X.2022.2114223

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3), 465–491. https://doi.org/10.3102/00028312032003465

Latifah, N., Hayat, M. S., & Khoiri, N. (2023). Potensi implementasi pembelajaran berdiferensiasi berorientasi ESD dalam projek IPAS aspek zat dan perubahannya. *Jurnal Penelitian Pembelajaran Fisika, 14*(2), 261–268. https://doi.org/10.26877/jp2f.v14i2.16955

Melesse, T., & Belay, S. (2022). Differentiating instruction in primary and middle schools: Does variation in students' learning attributes matter? *Cogent Education, 9*(1). https://doi.org/10.1080/2331186X.2022.2105552

Moghadam, Z. B., Narafshan, M. H., & Tajadini, M. (2023). The effect of implementing a critical thinking intervention program on English language learners' critical thinking, reading comprehension, and classroom climate. *Asian-Pacific Journal of Second and Foreign Language Education, 8*, Article 19. https://doi.org/10.1186/s40862-023-00188-3

Nsabayezu, E., Iyamuremye, A., Nahimana, J. P., Mukiza, J., Kampire, E., & Nsengimana, T. (2022). The progress in the application of rubric materials in chemistry teaching and students' learning enhancement during the 21st century: A systematic review. *Discover Education, 1*, Article 5. https://doi.org/10.1007/s44217-022-00005-y

Nusser, L., & Gehrer, K. (2025). Addressing heterogeneity in secondary education: Who benefits from differentiated instruction in German classes? *International Journal of Inclusive Education, 29*(6), 1568–1588. https://doi.org/10.1080/13603116.2020.1862407

Özcan, Z. Ç. (2016). The relationship between mathematical problem-solving skills and self-regulated learning through homework behaviours, motivation, and metacognition. *International Journal of Mathematical Education in Science and Technology, 47*(3), 408–420. https://doi.org/10.1080/0020739X.2015.1080313

Pozas, M., & Letzel-Alt, V. (2023). Teacher collaboration, inclusive education and differentiated instruction: A matter of exchange, co-construction, or synchronization? *Cogent Education, 10*(1). https://doi.org/10.1080/2331186X.2023.2240941

Rahmawati, Y., & Ridwan, A. (2017). Empowering students' chemistry learning: The integration of ethnochemistry in culturally responsive teaching. *Chemistry, 26*, 813–830. https://www.ceeol.com/search/article-detail?id=600081

Rahmawati, Y., Ridwan, A., Rahman, A., & Kurniadewi, F. (2019). Chemistry students' identity empowerment through ethnochemistry in Culturally Responsive Transformative Teaching (CRTT). *Journal of Physics: Conference Series, 1156*(1), Article 012032. https://doi.org/10.1088/1742-6596/1156/1/012032

Rahmian, L., Hod, Y., Yuan, G., & Zhang, J. (2025). Supporting students' inquiry through doubly authentic learning designs: Four configurations of interests, domain, and identity. *European Journal of Psychology of Education, 40*, Article 68. https://doi.org/10.1007/s10212-024-00818-5

Rodríguez, A. D. (2014). Culturally relevant books: Culturally responsive teaching in bilingual classrooms. *NABE Journal of Research and Practice, 5*(1), 173–196. https://doi.org/10.1080/26390043.2014.12067778

Santamaria, L. J. (2009). Culturally responsive differentiated instruction: Narrowing gaps between best pedagogical practices benefiting all learners. *Teachers College Record, 111*(1), 214–247. https://doi.org/10.1177/016146810911100105

Sedeňo, 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.

Singh, S. S., & Akar, H. (2021). Culturally responsive teaching: Beliefs of pre-service teachers in the Viennese context. *Intercultural Education, 32*(1), 46–61. https://doi.org/10.1080/14675986.2020.1844533

Strogilos, V., Lim, L., & Binte Mohamed Buhari, N. (2023). Differentiated instruction for students with SEN in mainstream classrooms: Contextual features and types of curriculum modifications. *Asia Pacific Journal of Education, 43*(4), 850–866. https://doi.org/10.1080/02188791.2021.1984873

Tan, C. (2017). Teaching critical thinking: Cultural challenges and strategies in Singapore. *British Educational Research Journal, 43*(5), 988–1002. https://doi.org/10.1002/berj.3295

Tiruneh, D. T., De Cock, M., & Elen, J. (2018). Designing learning environments for critical thinking: Examining effective instructional approaches. *International Journal of Science and Mathematics Education, 16*(6), 1065–1089. https://doi.org/10.1007/s10763-017-9829-z

Tomlinson, C. A. (2001). *How to differentiate instruction in mixed-ability classrooms* (2nd ed.). Association for Supervision and Curriculum Development.

Üce, M., & Ceyhan, İ. (2019). Misconception in chemistry education and practices to eliminate them: Literature analysis. *Journal of Education and Training Studies, 7*(3), 202–214. https://doi.org/10.11114/jets.v7i3.3990

Valiandes, S., & Neophytou, L. (2018). Teachers' professional development for differentiated instruction in mixed-ability classrooms: Investigating the impact of a development program on teachers' professional learning and on students' achievement. *Teacher Development, 22*(1), 123–138. https://doi.org/10.1080/13664530.2017.1338196

van Riesen, S. A. N., Gijlers, H., Anjewierden, A., & de Jong, T. (2018). The influence of prior knowledge on experiment design guidance in a science inquiry context. *International Journal of Science Education, 40*(11), 1327–1344. https://doi.org/10.1080/09500693.2018.1477263

Zielhuis, M., Sleeswijk Visser, F., Andriessen, D., & Stappers, P. J. (2024). How design professionals learn within collaborative research projects. *CoDesign*, 1–19. https://doi.org/10.1080/15710882.2023.2294271

***Fitriyuni Miralda Siregar (Corresponding Author)**
Department of Chemical Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta
Jl. Rawamangun Muka, Rawamangun, Pulo Gadung, East Jakarta, DKI Jakarta, Indonesia, 13220
Email: fitriyunimsiregar@gmail.com

Yuli Rahmawati
Department of Chemical Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta
Jl. Rawamangun Muka, Rawamangun, Pulo Gadung, East Jakarta, DKI Jakarta, Indonesia, 13220
Email: yrahmawati@unj.ac.id

Achmad Ridwan
Department of Chemical Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta
Jl. Rawamangun Muka, Rawamangun, Pulo Gadung, East Jakarta, DKI Jakarta, Indonesia, 13220
Email: achmadridwan@unj.ac.id