

INTEGRATING LEARNING STYLES AND MULTIPLE INTELLIGENCES WITHIN THE 5E LEARNING CYCLE TO IMPROVE STUDENTS' HIGHER-ORDER THINKING IN CHEMISTRY

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Abstract. *This study aims to analyze the effects of grouping strategies based on students' learning styles and levels of Multiple Intelligences (MI) on their Higher-Order Thinking Skills (HOTS) in chemistry learning within the 5E Learning Cycle model. A 2×3 factorial experimental design was employed, involving senior high school students in East Java who were categorized according to learning style (homogeneous or heterogeneous groups) and MI levels (high, moderate, or low). Research instruments included an MI questionnaire, a HOTS test developed from the revised Bloom's taxonomy indicators, and observation sheets for learning activities. Data were analyzed using two-way ANOVA and interaction tests. The findings revealed that both grouping strategies and MI levels had a significant effect on students' HOTS, with a meaningful interaction between the two factors. Students with higher MI levels who participated in homogeneous learning-style groups demonstrated the greatest improvement in HOTS, particularly in the analyzing and creating dimensions. Integrating learning styles and MI within the 5E model was proven to enhance the effectiveness of each learning phase by activating exploratory and reflective cognitive processes. Theoretically, this study extends the 5E model into a Differentiated Learning Cycle (DLC)—an adaptive constructivist approach that integrates students' learning profiles into the chemistry learning process. The findings contribute empirically to the development of differentiated instructional strategies aimed at enhancing students' HOTS and twenty-first-century scientific literacy.*

Keywords: *Learning Cycle (5E), Multiple Intelligences, Learning Styles, Higher-Order Thinking Skills (HOTS), Chemistry Learning*

INTRODUCTION

Higher-Order Thinking Skills (HOTS) are a fundamental component of twenty-first-century education. HOTS involve the ability to analyze, evaluate, and create based on deep conceptual understanding [1]. In the context of chemistry learning, these skills are particularly crucial, as students must grasp the interconnections among macroscopic, microscopic, and symbolic representations to fully interpret chemical phenomena [2]. However, results from the Programme for International Student Assessment (PISA)

indicate that Indonesian students' higher-order thinking abilities remain relatively low, particularly in the domain of science [3]. This finding highlights the urgent need for learning models that are more active, meaningful, and capable of fostering complex thinking processes.

One of the models that has been proven effective in fostering active and constructive learning is the Learning Cycle (LC), particularly the 5E version, which serves as a framework for inquiry-oriented instruction [4], [5]. This model consists of five sequential

stages—*Engage, Explore, Explain, Elaborate, and Evaluate*—that guide students in constructing their own knowledge through experiential learning. The constructivist-based LC approach has been widely implemented in chemistry education and has been shown to enhance students' conceptual understanding and scientific attitudes [6], [7] and has also been effectively applied in reaction rate learning to improve students' critical thinking skills [8]. However, the effectiveness of LC implementation often remains limited because instructional designs tend to be uniform and fail to accommodate students' individual differences [9].

Each student possesses distinct learning styles and Multiple Intelligences (MI). Learning styles describe an individual's preferred way of receiving and processing information—whether visual, auditory, reading/writing, or kinesthetic—as explained in previous studies [10], [11]. Meanwhile, the theory of multiple intelligences proposes that human intelligence is diverse, encompassing logical–mathematical, spatial, interpersonal, intrapersonal, linguistic, kinesthetic, and other types of intelligence [12], [13]. The interrelationship between learning styles and MI has also been empirically demonstrated, showing that students' dominant intelligences tend to influence their preferred learning modalities [14]. This theory emphasizes that learning success is strongly influenced by the extent to which students utilize their dominant intelligences.

The integration of learning styles, Multiple Intelligences (MI), and the Learning Cycle (LC) model can create a more personalized and differentiated approach to chemistry learning. Recent research indicates that inquiry-based chemistry instruction tailored to students' MI profiles can significantly enhance both engagement and learning outcomes [15]. This approach aligns with the principles of differentiated instruction, which emphasize the importance of adapting the content, process, and product of learning to meet individual student needs [16]. Therefore, combining the constructivist-based LC approach with MI-oriented instruction is expected to maximize students' learning potential and enhance their Higher-Order Thinking Skills (HOTS).

Several previous studies have demonstrated the effectiveness of the Learning

Cycle (LC) model and the Multiple Intelligences (MI)-based approach when applied separately to improve students' learning outcomes [17], [18]. However, studies that integrate these two approaches simultaneously within the context of high school chemistry instruction are still limited. Moreover, most earlier research has focused primarily on improving conceptual understanding rather than directly examining the impact of integrating learning styles and MI on students' higher-order thinking skills (HOTS). Therefore, this study aims to address this gap by analyzing the effects of integrating learning styles and MI within the LC model on the development of HOTS in chemistry learning.

The urgency of this research lies in the need for a chemistry learning model that is not only oriented toward conceptual mastery but also adaptive to students' individual differences. Conceptually, this study introduces the integration of the Learning Cycle (5E) model with differentiation based on learning styles and Multiple Intelligences (MI) into a new approach referred to as the “Differentiated Learning Cycle.” This approach aims to facilitate students in learning according to their dominant potentials while simultaneously stimulating the development of Higher-Order Thinking Skills (HOTS) through exploratory and reflective learning stages.

The methodological novelty of this research lies in the use of a 2×3 factorial design, which enables a simultaneous analysis of two factors—grouping strategies based on learning styles and levels of Multiple Intelligences (MI)—as well as their interaction effects on students' Higher-Order Thinking Skills (HOTS). The empirical contribution of this study is to provide quantitative evidence of the relationship between students' individual characteristics and instructional strategies in achieving HOTS. Meanwhile, its practical contribution is the development of a chemistry learning model that can be easily adapted by teachers who emphasize differentiated instruction.

The study provides additional empirical support for the present research by reinforcing its foundational basis [19] and further supported by recent findings on HOTS-based assessment in chemistry learning [20]. It was found that students' Higher-Order Thinking

Skills (HOTS) in solving chemistry problems remain low when the instructional approach is not aligned with their individual characteristics. Therefore, integrating the Learning Cycle (LC) model with learning styles and Multiple Intelligences (MI), particularly in the context of reaction rate learning, has the potential to offer an innovative solution to this issue.

Based on the theoretical framework and empirical findings described above, this study is designed to examine the extent to which the integration of learning styles and Multiple Intelligences (MI) within the Learning Cycle (LC) model influences senior high school students' Higher-Order Thinking Skills (HOTS) in chemistry learning. Using a 2×3 factorial design, this research analyzes the main effects of both variables as well as the interaction between them on students' HOTS.

Grounded in this framework, the hypotheses of this study are formulated as follows:

1. **H₁:** There is a significant difference in students' Higher-Order Thinking Skills (HOTS) between those who learn in groups based on learning styles and those who learn in heterogeneous groups.
2. **H₂:** There is a significant difference in students' Higher-Order Thinking Skills (HOTS) among students with high, moderate, and low levels of Multiple Intelligences (MI).
3. **H₃:** There is a significant interaction between grouping strategies based on learning styles and the levels of Multiple Intelligences (MI) on students' Higher-Order Thinking Skills (HOTS) in chemistry learning.

METHOD

Research Design

This study employed a quasi-experimental method with a 2×3 factorial design. This design was used to analyze the effects of two independent variables on one dependent variable, as well as the interaction between them.

- a) The first independent variable was the student grouping strategy, which consisted of two levels:
 - (1) Grouping based on learning styles (*learning style grouping*)
 - (2) Heterogeneous grouping (without considering learning styles)

- b) The second independent variable was the level of students' Multiple Intelligences (MI), which consisted of three levels: high, moderate, and low.

- c) The dependent variable was students' Higher-Order Thinking Skills (HOTS) in chemistry learning.

This 2×3 factorial design enabled the researcher to examine not only the main effects of each factor but also the interaction between grouping strategies and MI levels on students' HOTS, as suggested by previous studies [15], [17], [19].

Population and Sample

The population of this study consisted of all eleventh-grade senior high school students at one selected senior high school in East Java Province during the 2025/2026 academic year. The sample was determined using a purposive sampling technique, which involved selecting schools with equivalent characteristics in terms of curriculum, laboratory facilities, and students' academic backgrounds.

The total sample consisted of 120 students, divided into six experimental groups according to the factorial design:

2 (grouping strategies) \times 3 (MI levels).

Each group comprised 20 students. The sample distribution was arranged so that the proportions of gender, prior achievement, and MI level were relatively balanced across groups, ensuring the initial homogeneity of the sample.

Research Instruments

Three types of instruments were used in this study:

- a) Learning Style Inventory (VARK)

This inventory was developed based on the model that measures students' learning preferences in four modalities—visual, auditory, reading/writing, and kinesthetic [11]. It consisted of 16 multiple-choice items. The content validity was examined by two experts in chemistry education, and its reliability showed a Cronbach's α value of 0.82.

- b) Multiple Intelligences (MI) Test

This test was adapted from the MI scale and was further modified to fit the context of chemistry learning [12], [13], [15]. It consisted of 40 items with a Cronbach's α reliability coefficient of 0.86. The scores

were used to classify students into high, moderate, and low MI categories.

- c) **Higher-Order Thinking Skills (HOTS) Test**
This test was developed based on the revised taxonomy and included three main indicators: analyzing, evaluating, and creating [1]. It comprised 10 open-ended questions. The content and construct validity were reviewed by three experts in chemistry education, and the pilot test produced a Cronbach's α reliability value of 0.88.

Research Procedure

The research was conducted over six learning sessions through six main stages following the Learning Cycle (5E) model [5]:

- Engage**
Students were presented with a contextual chemistry problem (i.e., reaction energy changes).
- Explore**
Student groups conducted experiments or simulations according to their dominant learning styles and Multiple Intelligences (MI).
- Explain**
Students discussed their findings and explained the concepts using visual, verbal, or kinesthetic approaches based on their learning profiles.
- Elaborate**
The teacher assigned follow-up tasks that required students to apply the learned concepts to new situations.
- Evaluate**
Assessment was carried out through the HOTS test and students' learning reflections.

Throughout the learning process, the teacher acted as a facilitator and ensured that each stage of the cycle aligned with the students' learning styles and MI needs.

Data Analysis Technique

Data were analyzed using SPSS version 26.0 through the following procedures:

- Preliminary assumption tests included the normality test (Kolmogorov–Smirnov) and the homogeneity of variance test (Levene's Test).

- The main hypothesis testing was carried out using Two-Way Analysis of Covariance (ANCOVA) with the pretest score as a covariate. The results were used to examine the main effects of grouping strategies, MI levels, and their interaction on students' Higher-Order Thinking Skills (HOTS).
- If a significant interaction was found, a post hoc Tukey HSD test was performed to determine pairwise differences among categories.
- All analyses were conducted at a significance level of $\alpha = 0.05$.

ANCOVA analysis was chosen because it is able to control confounding variables and assess the influence of two factors simultaneously on the dependent variable [21].

RESULT AND DISCUSSION

Result

Data Description

This study involved 120 senior high school students from East Java who participated in chemistry learning using the Learning Cycle (5E) model combined with grouping strategies based on learning styles and levels of Multiple Intelligences (MI). Students' Higher-Order Thinking Skills (HOTS), which included the indicators of analyzing, evaluating, and creating, were measured using an open-ended test consisting of 10 items. Table 1 presents the mean (M) and standard deviation (SD) of students' HOTS scores across the experimental groups.

Table 1. Mean and Standard Deviation of Students' HOTS Scores Based on Grouping Strategies and MI Levels

Grouping Strategy	MI Level	n	M	SD
LS based	High	20	82.15	5.24
LS based	Moderate	20	77.90	5.78
LS based	Low	20	73.40	6.05
Hetero-geneous	High	20	77.10	5.87
Hetero-geneous	Moderate	20	73.85	6.33
Hetero-geneous	Low	20	68.45	6.90

As presented in Table 1, students who learned in groups based on learning styles consistently achieved higher HOTS scores than those in heterogeneous groups across all MI levels. Within the learning-style grouping,

students with high MI obtained the highest mean score ($M = 82.15$, $SD = 5.24$), followed by those with moderate MI ($M = 77.90$, $SD = 5.78$) and low MI ($M = 73.40$, $SD = 6.05$).

In contrast, students in heterogeneous groups showed lower HOTS performance, with mean scores decreasing from high MI ($M = 77.10$, $SD = 5.87$) to moderate MI ($M = 73.85$, $SD = 6.33$) and low MI ($M = 68.45$, $SD = 6.90$). Overall, the descriptive results suggest that grouping students according to their learning styles and MI levels may positively influence the development of higher-order thinking skills in chemistry learning.

Assumption Testing

The normality test using the Kolmogorov–Smirnov procedure indicated that the data were normally distributed ($p > 0.05$) across all groups. The homogeneity of variance test using Levene's Test also showed a non-significant result ($F(5,114) = 1.27$, $p = 0.28$), confirming that the assumption of homogeneity was met. Therefore, the analysis proceeded with a Two-Way Analysis of Covariance (ANCOVA) using the pretest scores as a covariate.

Hypothesis Testing Results

Table 2. Results of Two-Way ANCOVA for the Effects of Grouping Strategies and MI Levels on Students' HOTS

Source of Variation	df	F	Sig.	Partial η^2
Grouping Strategy (A)	1	14.82	0.000	0.115
MI Level (B)	2	9.74	0.000	0.146
Interaction (A×B)	2	5.61	0.005	0.090
Error	114	—	—	—

The results of the analysis show that:

- The grouping strategy based on learning styles had a significant effect on students' Higher-Order Thinking Skills (HOTS), $F = 14.82$, $p < 0.05$. This finding indicates that students grouped according to their learning styles demonstrated higher levels of thinking ability compared to those placed in heterogeneous groups.

- The level of Multiple Intelligences (MI) also had a significant effect on students' HOTS, $F = 9.74$, $p < 0.05$.

This means that students with high MI levels obtained higher HOTS scores than those with moderate and low MI levels.

- A significant interaction was found between grouping strategies and MI levels on students' HOTS, $F = 5.61$, $p < 0.05$. This result implies that the effect of grouping strategy on HOTS depended on students' MI levels.

To clarify the interaction effect between grouping strategies and levels of Multiple Intelligences (MI) on students' Higher-Order Thinking Skills (HOTS), the relationship pattern is illustrated in Figure 1.

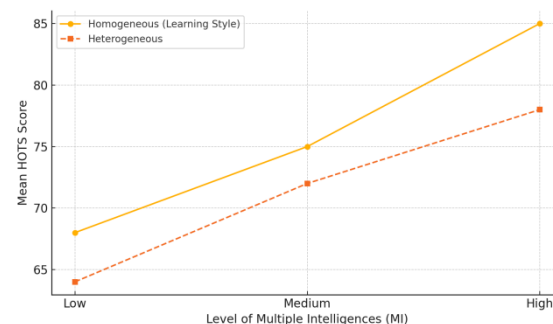


Figure 1. Interaction between Grouping Strategies and MI Levels on Students' HOTS

Figure 1 illustrates that students' HOTS scores increased along with higher levels of Multiple Intelligences (MI) under both grouping strategies. However, the steepest increase occurred in the homogeneous group (based on learning styles), indicating that aligning instructional strategies with students' learning styles exerts a stronger influence on the development of HOTS, particularly among students with high MI levels.

Post Hoc Analysis

A Tukey HSD post hoc test was conducted to determine which groups showed significant differences. The results revealed that:

- Within the learning-style-based grouping strategy, significant differences in HOTS were found between the high–moderate MI and high–low MI groups ($p < 0.05$).
- Within the heterogeneous grouping strategy, a significant difference was

observed only between the high and low MI groups ($p < 0.05$).

These findings indicate that the integration of the Learning Cycle (5E) model with students' learning style and MI profiles effectively enhances Higher-Order Thinking Skills (HOTS) in a more consistent manner.

Overall, the findings of this study indicate that: 1) The grouping strategy based on learning styles resulted in higher HOTS achievement than the heterogeneous grouping; 2) Students with high levels of Multiple Intelligences (MI) demonstrated better cognitive performance during chemistry learning activities designed through the Learning Cycle (5E) model; and 3) The interaction between the two variables highlights the importance of instructional designs that are adaptive to students' individual characteristics. These results reinforce the conclusion that implementing instructional approaches based on Multiple Intelligences (MI) and learning styles can optimize student engagement and promote complex thinking in science and chemistry contexts [15], [19].

Discussion

The results of this study indicate that the grouping strategy based on learning styles and the level of Multiple Intelligences (MI) had a significant effect on students' Higher-Order Thinking Skills (HOTS) in chemistry learning using the Learning Cycle (5E) model. Furthermore, a significant interaction between these two factors was observed, suggesting that the effectiveness of instructional strategies is strongly influenced by students' cognitive characteristics and dominant intelligences. These findings emphasize the importance of implementing instructional approaches that are not uniform but instead take into account the comprehensive cognitive profiles of individual learners.

The Effect of Grouping Strategy on HOTS

Statistical analysis showed that students grouped according to their learning styles achieved higher HOTS scores than those grouped heterogeneously. This finding supports the view that learning becomes more effective when instructional strategies are aligned with individual learning preferences [10], [11]. In the context of chemistry learning, this alignment is particularly important because students often deal with abstract representations

that require strong conceptual visualization and advanced analytical skills [2]. Inquiry- and STEM-based chemistry learning modules have also been shown to effectively foster students' creative and higher-order thinking skills [22].

In the Learning Cycle (5E) model, the *Explore* and *Explain* phases play a crucial role in enabling students to construct and reconstruct concepts through visual, auditory, or kinesthetic learning experiences. When the learning process is aligned with how students process information, cognitive activities such as analysis, evaluation, and synthesis become more focused and productive [5], [6].

This relationship can be explained cognitively, as each phase of the 5E model is designed to activate the principles of retrieval, elaboration, and metacognitive reflection, which enable students to meaningfully connect new experiences with prior knowledge and ultimately strengthen higher-order thinking processes [23]. In addition, long-term implementation of the 5E model has been shown to enhance conceptual retention and reflective thinking skills rather than merely improving short-term learning outcomes [24].

Meanwhile, differentiation based on learning styles can enhance cognitive engagement, particularly when combined with inquiry-based approaches such as the 5E model [9]. However, these findings should be interpreted with caution, as experimental evidence regarding the effectiveness of the learning styles matching approach remains mixed [25], [26]. Nevertheless, this study provides new empirical evidence that grouping students according to their learning styles, when integrated with a constructivist framework, can significantly strengthen the development of higher-order thinking skills (HOTS).

The Effect of Multiple Intelligences Levels on HOTS

The finding that students with high levels of Multiple Intelligences (MI) demonstrated better HOTS performance than those with moderate and low MI levels is consistent with the theory of multiple intelligences, which posits that individuals with strong logical-mathematical, intrapersonal, and spatial intelligences tend to excel in analytical reasoning and scientific problem-solving processes [12], [13]. Logical-mathematical

intelligence has also been found to significantly contribute to students' conceptual understanding and analytical reasoning in chemistry learning [27].

In the context of chemistry learning, students with high levels of Multiple Intelligences (MI) are better able to transfer concepts across macroscopic, microscopic, and symbolic representations and apply them to new situations—an ability that lies at the core of higher-order thinking. This study supports the findings of previous research showing that the systematic application of MI theory can enhance learning outcomes and complex thinking skills across various scientific disciplines [28].

Furthermore, the integration of Multiple Intelligences (MI) into inquiry-based chemistry learning has been shown to enhance students' active engagement, facilitate the exploration of ideas, and deepen conceptual understanding. Thus, the integration of MI not only adds variety to the learning process but also enriches the cognitive dimension at each stage of the Learning Cycle [15].

Interaction between Grouping Strategy and MI Level on HOTS

The significant interaction between grouping strategies and levels of Multiple Intelligences (MI) indicates that the effect of learning styles on HOTS is not universal but depends on students' intelligence profiles. Students with high MI levels gain greater benefits when learning in groups aligned with their dominant learning styles, as they are able to integrate logical, interpersonal, and reflective intelligences into scientific activities.

The sharper increase in HOTS scores observed among students with high MI levels in the learning-style grouping suggests a synergy between differentiated instruction and the Learning Cycle (5E) model. This synergy is grounded in the constructivist principle that knowledge is built through experiences aligned with learners' cognitive structures and dominant potentials [5], [16].

This finding is consistent with previous research showing that students' HOTS significantly improve when inquiry-based and Learning Cycle-oriented instruction is implemented [19], and is further supported by studies applying the Learning Cycle model in reaction rate topics to enhance students' critical

thinking skills [8]. Accordingly, this study provides an empirical foundation for implementing adaptive chemistry instruction that integrates Multiple Intelligences (MI), learning styles, and the stages of the Learning Cycle into a new conceptual model: the Differentiated Learning Cycle (DLC).

Implications for Chemistry Learning Practice ***(1) Theoretical Implications***

This study strengthens the theoretical foundation of the Learning Cycle (5E) model within the framework of cognitive constructivism by demonstrating that its effectiveness depends on the alignment between students' characteristics and the learning experiences provided. These findings support the view that each phase of the 5E model stimulates the processes of retrieval, elaboration, and metacognitive reflection, which in turn foster the development of Higher-Order Thinking Skills (HOTS) [23].

The integration of learning styles and Multiple Intelligences (MI) expands the theoretical foundation of the 5E model into a more adaptive and reflective learning framework. This approach reinforces the view that the sustainability of conceptual learning can only be achieved when students are actively engaged in reflective thinking processes that are tailored to individual differences [24].

Conceptually, this study provides a theoretical enrichment through the development of the Differentiated Learning Cycle (DLC)—an enhanced version of the 5E model optimized through instructional differentiation based on students' learning profiles (learning style \times MI). This model contributes a new perspective to constructivist theory by emphasizing that success in chemistry learning is determined not only by cognitive stages but also by the alignment between instructional structure and students' individual potentials.

(2) Practical Implications

The findings of this study have direct implications for chemistry teachers at the senior high school level. Teachers are encouraged to assess students' learning styles and MI profiles at the beginning of the semester so that classroom activities can be designed more purposefully. However, in practice, the implementation of differentiated instruction in

chemistry classrooms often presents significant challenges for teachers, particularly in terms of time constraints, classroom management, and limited pedagogical resources [29]. Therefore, the proposed Differentiated Learning Cycle (DLC) model may serve as a practical framework to address these challenges by providing structured yet flexible guidance for adaptive chemistry instruction.

In addition, teachers need to develop contextual HOTS assessment instruments that challenge students' analytical and creative thinking abilities, such as open-ended experiments, Problem-Based Learning (PBL) projects, or chemistry case studies drawn from real-life situations. This perspective aligns with the view that learning activities involving the dimensions of analyzing, evaluating, and creating constitute the core of HOTS development [1].

Meta-analytic evidence supports these findings, showing that the combination of exploratory and reflective activities within the learning cycle model produces a large effect size on the scientific thinking skills of chemistry students across different educational levels [30].

Therefore, teachers are encouraged to use the results of MI and learning style assessments as the basis for designing adaptive instruction that promotes active participation, conceptual understanding, and the enhancement of Higher-Order Thinking Skills.

Beyond its implications for teachers, the findings of this study also provide practical policy directions for curriculum developers and educational institutions to integrate learning style and MI assessments into competency-based learning systems. This approach aligns with the spirit of the Indonesian curriculum, which emphasizes differentiated and student-centered learning.

The novelty of this study lies in the integration of the Learning Cycle (5E) model with the principles of differentiated instruction based on learning styles and Multiple Intelligences (MI)—a combination that has been rarely explored in the context of Indonesian high school chemistry learning. This approach led to the development of a new conceptual model, the Differentiated Learning Cycle (DLC), which serves as an adaptive and reflective constructivist framework.

The theoretical contribution of this research is the empirical evidence showing that the combination of learning style \times MI enhances the effectiveness of the Learning Cycle model in improving students' Higher-Order Thinking Skills (HOTS). Its practical contribution lies in providing chemistry teachers with a framework for designing inclusive learning that emphasizes individual student potential.

Overall, the findings affirm that chemistry learning which takes into account students' individual characteristics—through the integration of learning styles and MI levels within the Learning Cycle (5E) framework—can effectively optimize the development of Higher-Order Thinking Skills, thereby reinforcing the position of differentiated approaches as a promising strategy for advancing twenty-first-century chemistry education that is constructivist, adaptive, and evidence-based, as supported by empirical evidence from previous studies [23], [24], [25], [26], [28], [30], [31].

CONCLUSIONS AND SUGGESTIONS

This study concludes that chemistry learning based on the Learning Cycle (5E), when integrated with grouping strategies according to students' learning styles and levels of Multiple Intelligences (MI), is proven to be effective in enhancing students' Higher-Order Thinking Skills (HOTS). This effectiveness arises from the alignment between the cognitive structure of the 5E stages and the differentiated instructional approach that accommodates students' individual learning preferences and dominant intelligences.

This model not only reinforces the principles of cognitive constructivism but also provides an empirical foundation for the development of a new conceptual framework, the Differentiated Learning Cycle (DLC)—an adaptive, reflective, and learner-centered instructional approach.

Thus, chemistry learning that takes into account the diversity of students' learning styles and Multiple Intelligences (MI) not only enhances learning outcomes but also fosters the development of critical, creative, and reflective thinking skills—essential competencies for meeting the challenges of twenty-first-century education.

This study recommends the implementation of the *Differentiated Learning Cycle (DLC)* model, which integrates the Learning Cycle (5E), learning styles, and Multiple Intelligences (MI), as an effective strategy to enhance students' Higher-Order Thinking Skills (HOTS) in chemistry learning. Teachers are encouraged to identify students' learning profiles at the beginning of instruction to support adaptive and meaningful learning processes. Future research should examine the effectiveness of this model across broader contexts, including different chemistry topics, educational levels, and additional variables such as learning motivation, self-efficacy, and collaborative skills to strengthen its external validity.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to the principal and chemistry teachers of the selected senior high school for their valuable support and assistance throughout the research process. The authors also extend their appreciation to the students who participated in this study.

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