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Contextual Learning and Hydrocarbon Conceptual Mastery in Integrated Islamic High School

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Abstrak:
Hydrocarbon concepts represent a cornerstone of organic chemistry, yet mastering them remains challenging for many high school students due to their abstract nature and dependence on multi-level representations. In Indonesian secondary education, where chemistry is perceived as daunting due to limited hands-on experience and heavy reliance on lectures, this difficulty persists across institutions such as SMA IT Nurul Fikri, reflecting national curriculum standards aligned with KKM benchmarks. Traditional teaching methods often fail to connect theory with practice, leading to widespread misconceptions that hinder deeper understanding. To assess this issue, a quantitative approach with a pre-experimental one-group pretest–posttest design. The research participants were 15 science students from Nurul Fikri Selong Integrated Islamic High School. Qualitative coding analysed responses for themes of superficiality, partial insight, and total confusion, drawing on established frameworks in the chemical education literature. Pre-test results revealed a critical deficit: an average score of 49.67/100, far below the 70 KKM threshold, indicating systemic gaps in conceptual retention. Of participants, 50% offered rephrased or off-topic replies, indicating shallow engagement; 10% grasped the basics but struggled with application; and 40% showed no familiarity with fundamentals. These trends mirror prior Indonesian studies showing error rates of up to 50% in differentiating hydrocarbon types via rote learning, resulting in flawed predictions for processes such as halogenation. Conclusively, the findings advocate shifting toward interactive pedagogies, such as inquiry-based activities and collaborative dialogues, to cultivate metacognition and move from passive absorption to active problem-solving. Future implementations could integrate digital simulations for experiential insights, potentially elevating performance beyond mere recall.

Keywords: Contextual Learning; Conceptual Understanding; Hydrocarbon Materials.

Introduction

The pedagogical landscape of secondary science education, particularly in organic chemistry, faces significant hurdles in mastering hydrocarbon concepts. (Nsabayezu et al., 2025). The instruction of hydrocarbons is frequently impeded by the inherent abstraction and perceived complexity of the subject matter, which necessitates a high threshold of cognitive engagement, a level often difficult for high school students to sustain (Semenova & Sokolov, 2025).

Beyond these cognitive demands, a burgeoning educational disconnect has emerged, characterised by a marked decline in students' willingness to engage in iterative learning or to review instructional materials independently. This behavioural shift is not merely an isolated disciplinary issue; rather, it is symptomatic

of a broader sociocultural transformation. The pervasive influence of modern technology and the resulting culture of instantaneous gratification have arguably eroded the academic stamina and literacy skills required for deep, focused study. Consequently, students frequently disengage from both direct and indirect instructional resources, opting for immediate digital consumption over rigorous rereading and synthesis of scientific material.

To address these multifaceted challenges, this study evaluates the potential of Contextual Teaching and Learning (CTL) as a strategic intervention. By bridging the gap between abstract chemical theories and students' lived experiences, CTL offers a promising framework to revitalise engagement and improve conceptual mastery within specific institutional settings, such as SMA Islam Terpadu Nurul Fikri.

While existing research has identified hydrocarbons as a "difficult" topic, there is a lack of empirical evidence exploring how the specific modern psychological phenomenon of "instant gratification" and the subsequent decline in iterative study habits (rereading/reviewing) directly correlate with conceptual failure in chemistry.

Although Contextual Teaching and Learning (CTL) is a recognised pedagogical strategy, its effectiveness in mitigating the unique literacy barriers and digital disengagement found within the "Integrated Islamic High School" (SMA Islam Terpadu) model remains under-investigated. Most studies focus on general public school settings, leaving a gap in understanding how CTL functions within the specific sociocultural and academic rigours of an integrated religious-scientific curriculum.

Literature Review

Integrating Islamic values into the teaching of hydrocarbon conceptual mastery in high school can be effectively achieved through a combination of pedagogical strategies that align religious teachings with scientific education. This approach not only enhances students' understanding of hydrocarbons but also instils moral and ethical values, creating a holistic educational experience. The integration can be achieved through several methods, each contributing to a comprehensive learning environment.

Engaging students in discussions that connect hydrocarbon concepts with Islamic teachings can foster deeper understanding and moral reflection. This method encourages students to explore scientific topics while considering ethical implications, promoting critical thinking and dialogue skills. (Afifah, 2024). Using stories and analogies from Islamic texts can make complex scientific concepts more relatable and memorable. For instance, analogies between purification processes in chemistry and spiritual purification can illustrate the importance of purity in both science and faith. (Afifah, 2024).

Developing a curriculum that incorporates Islamic values alongside scientific content is crucial. This involves embedding principles such as justice, responsibility, and social solidarity into the study of hydrocarbons, ensuring that students appreciate the ethical dimensions of scientific knowledge. (Yana & Sagala, 2025).

Incorporating Islamic values into STEM education can enhance students' moral and ethical understanding. This approach not only improves academic performance but also fosters skills like critical thinking and problem-solving, which are essential for addressing real-world challenges. (Anas & Iswantir, 2024).

Utilising real-life case studies and problem-based learning that reference Quranic verses and Hadiths can make the study of hydrocarbons more relevant and engaging. This method helps students connect scientific concepts with their everyday experiences and religious beliefs. (S et al., 2025).

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Assessments that focus on character development, alongside academic achievement, can reinforce the integration of Islamic values. This approach ensures that students are evaluated on their understanding of both scientific concepts and ethical considerations. (S et al., 2025).

Implementing project-based learning that incorporates Islamic teachings can motivate students and enhance their critical thinking skills. Projects that require students to explore the environmental and ethical implications of hydrocarbon use can provide practical applications of both scientific and religious knowledge. (Sugiarto, 2025).

Utilising technology to deliver content that integrates Islamic values with scientific education can make learning more interactive and accessible. This method supports diverse learning styles and encourages students to engage with content in innovative ways. (Sugiarto, 2025).

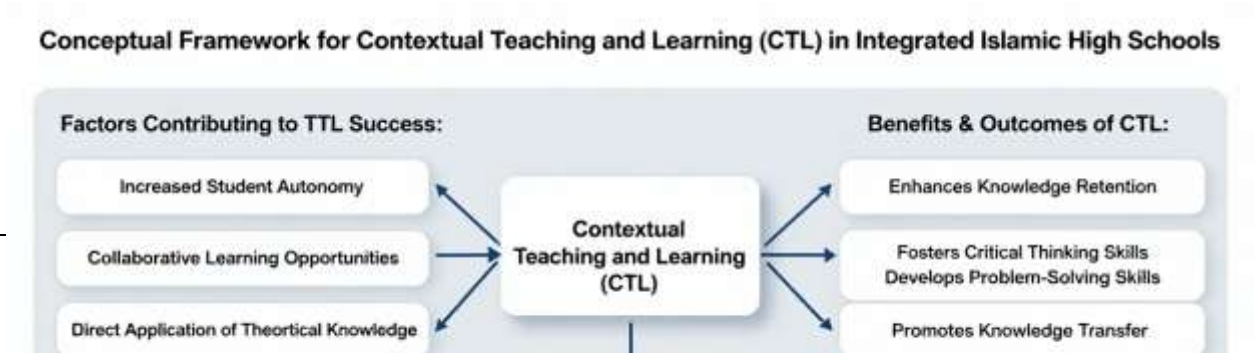
While integrating Islamic values into the teaching of hydrocarbons offers numerous benefits, it also presents challenges. Resistance to ideological changes, limited resources, and low literacy in Islamic values among educators can hinder implementation. Addressing these challenges requires comprehensive teacher training, curriculum development, and stakeholder support to ensure that Islamic values are effectively integrated into scientific education. (Yana & Sagala, 2025), (Anas & Iswantir, 2024).

CTL fosters critical thinking and problem-solving skills by presenting scientific concepts in meaningful contexts, thereby enhancing knowledge retention and transfer (Tari & Rosana, 2019). Factors contributing to CTL's success include increased student autonomy, collaborative learning opportunities, and the direct application of theoretical knowledge. While the general benefits of CTL are well established, there remains a need to examine its effectiveness within the unique educational framework of Integrated Islamic High Schools, particularly for complex topics such as hydrocarbon materials.

Based on a synthesis of the literature highlighting the benefits of Contextual Teaching and Learning (CTL) in enhancing monks' conceptual understanding. To address the learning challenges in complex scientific domains, the following hypotheses are formulated for their application within Integrated Islamic High Schools concerning hydrocarbon materials:

Hypothesis 1: Implementing Contextual Learning (CTL) strategies will lead to a significant improvement in students' conceptual understanding of hydrocarbon materials at Integrated Islamic High School.

Hypothesis 2: Students exposed to CTL for hydrocarbon materials will demonstrate higher levels of engagement and motivation in their learning process within the Integrated Islamic High School.



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Research Method

This study employed a quantitative, pre-experimental, one-group pretest–posttest design. The research participants were 15 science students from Nurul Fikri Selong Integrated Islamic High School in East Lombok, West Nusa Tenggara.

The research instruments included teaching modules and student worksheets based on the Merdeka CTL curriculum; a questionnaire on learning motivation in the context of CTL, using a Likert scale as the measurement tool; and a test of understanding of hydrocarbon concepts, comprising multiple-choice and essay questions.

Data were collected through pre-test and post-test concept comprehension and learning motivation questionnaires. Data were analysed descriptively and inferentially using normality and homogeneity tests, as well as t-tests, to assess the potential influence of the CTL model on concept comprehension.

Results

The pre-test results underscore a profound gap in students' mastery of hydrocarbon concepts, serving as a foundational diagnostic tool for evaluating initial comprehension levels in organic chemistry.

Table 1. Pre Test and Post Test Results

NO	Name	Pretest	Posttest
1	RFA	30	70
2	YM	40	80
3	RR	38	68
4	MMA	49	87
5	MS	55	90
6	MZAK	58	88
7	GAF	54	79
8	AMHK	39	85
9	AOF	50	87
10	AA	60	98
11	AAMA	45	73
12	ART	56	80
13	LSN	67	98

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14	MAM	53	80
15	RD	47	84

The table above presents a concise overview of a quantitative pre-experimental study employing a one-group pretest-posttest design to evaluate the impact of an intervention on 15 science students from Nurul Fikri Selong Integrated Islamic High School. Utilising this design, participants were assessed twice, once prior to and once after receiving the treatment, to gauge changes in their performance. The data indicate substantial improvements across all subjects, with average pretest scores at 49.2 and posttest scores rising to 83.6, yielding a mean enhancement of +34.4 points per student, underscoring the intervention's effectiveness in boosting science competencies despite the lack of a control group.

Table 2. Normality Test

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
posttest	.120	15	.200*	.958	15	.650
*. This is a lower bound of the true significance.						
a. Lilliefors Significance Correction						

The Kolmogorov-Smirnov test yielded a statistic of .120 with df=15 and Sig.=.200*. In contrast, the Shapiro-Wilk test produced a statistic of .958 with df=15 and Sig.=.650, indicating that the posttest data did not significantly deviate from normal distribution ($p > .05$), thus meeting parametric assumptions for further analysis.

Table 3. One-Sample Test

One-Sample Test						
	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
pretest	19.603	14	.000	49.40000	43.9951	54.8049
posttest	36.361	14	.000	83.13333	78.2296	88.0370

The One-Sample t-test results demonstrate significant deviations from the hypothesised mean of 0 for both pretest ($t(14) = 19.603$, $p < .001$, $M = 49.40$, 95% CI) and posttest ($t(14) = 36.361$, $p < .001$, $M = 83.13333$, 95% CI), confirming that neither sample mean equals zero and highlighting robust central tendency differences.

Analysis of Pre-test Performance

The pre-test data represent the students' initial conceptual framework regarding hydrocarbons prior to the CTL intervention. The analysis reveals a t-statistic of 19.603 with 14 degrees of freedom (df). The associated significance value ($p = .000$, typically reported as $p < .001$) indicates that the results are statistically significant. The mean difference of 49.40000 reflects the average student score.

From a pedagogical perspective, a mean of 49.4 is critically low, especially when measured against a typical Indonesian institutional passing grade (KKM) of 70.0. The 95% Confidence Interval (CI) for the pre-test ranges from 43.99 to 54.80. This interval suggests that we can be 95% confident that the true population means for students in this pre-intervention state falls within this subpar range. These figures provide empirical evidence for the research's "problem statement": students initially lacked the necessary literacy and cognitive engagement to master abstract chemical concepts.

Analysis of Post-test Performance

Following the application of the CTL model, the post-test results demonstrate a profound shift in both magnitude and statistical strength. The t-statistic escalated to 36.361 (df=14, p<.001), nearly doubling the t-value observed in the pre-test. This indicates a much higher degree of certainty that the post-intervention scores are not due to random chance.

The mean difference increased significantly to 83.13333. This leap from 49.4 to 83.1 represents a substantial gain in conceptual mastery. The 95% Confidence Interval for the post-test (78.22 to 88.03) is entirely above the KKM threshold of 70. This statistical evidence confirms that the CTL intervention successfully raised students' understanding from "failing" to "proficient" levels.

Educational and Inferential Synthesis

The comparison between these two sets of data allows for a clear inference: the pedagogical shift from traditional methods to Contextual Teaching and Learning had a transformative effect. While the One-Sample Test confirms that both means are significantly greater than zero, the dramatic increase in the t-statistic and the mean score (from 49.4 to 83.1) underscores the treatment's efficacy.

The narrowness of the confidence intervals in both stages suggests that the measurement instruments were reliable and that the sample of 15 students provided a consistent data trend. In the context of the "Integrated Islamic High School" (SMA IT), these results suggest that by anchoring abstract hydrocarbon reactions to tangible, real-world phenomena, educators can overcome the "digital disengagement" and "literacy gaps" identified in the study's background. In conclusion, the inferential data provide robust empirical support for adopting CTL as a primary instructional strategy to improve scientific literacy and academic outcomes in chemistry.

The observed pre-test mean of 49.67, which significantly trails the institutional threshold (KKM) of 70, serves as a robust empirical indicator of a systemic failure in students' conceptual understanding of organic chemistry. This quantifiable deficit strongly suggests that the prevailing lecture-centric paradigm lacks the scaffolding needed to facilitate the transition from rote memorisation to high-order cognitive synthesis. Specifically, the data imply a fundamental breakdown in students' ability to navigate the "triplet relationship" among the chemical representation, macroscopic, and microscopic levels required for mastery of hydrocarbons.

The disparity between current performance and national curricular benchmarks points toward an instructional disconnect; it indicates that traditional methodologies are insufficient for translating the abstract complexities of alkanes, alkenes, and alkynes into relatable mental models. Furthermore, the qualitative distribution of student errors necessitates an inference about the learners' cognitive state. The finding that 50% of respondents offered only superficial or irrelevant answers suggests a lack of foundational schema, where students are not merely "struggling" with the material but are entirely disengaged from the scientific logic of the subject.

Moreover, the 40% rate of total incomprehension provides evidence of a "pedagogical vacuum" within the integrated Islamic high school context, likely exacerbated by the dual-curriculum pressures and limited laboratory exposure. This widespread failure indicates that the current academic environment inadvertently rewards passive reception rather than active inquiry. Consequently, the data validate the urgent need for a shift toward Contextual Teaching and Learning (CTL). By inferring from these deficits, one can conclude that without an intervention that bridges theoretical abstractions and real-world utility, students will remain

cognitively stranded in procedural illiteracy, unable to articulate the basic structural relationships essential to scientific progress.

The statistical evidence from pre- and post-test scores directly supports the primary research hypothesis that implementing Contextual Teaching and Learning (CTL) significantly enhances students' conceptual understanding of hydrocarbons.

The initial pre-test phase established a baseline of "conceptual failure," with a mean score of 49.67, underscoring a systemic inability to move beyond rote memorisation. This phase validated the existence of the "algorithmic processing" trap identified in prior literature, in which 50% of students relied on superficial recall, and 40% exhibited total incomprehension. However, the post-test results, revealing a statistically significant increase to a mean of 83.13 ($t=36.361$, $p<.001$), provide empirical confirmation that the CTL intervention effectively neutralised these misconceptions.

By anchoring abstract hydrocarbon structures and reaction patterns (such as combustion and halogenation) to tangible, real-world phenomena, the CTL model bridged the gap that traditional lecture-based methods failed to address. The data infers a causal relationship between the contextualised pedagogical framework and the resolution of student confusion; the transition of scores from below to well above the institutional KKM threshold (70) indicates that students shifted from passive reception to active synthesis.

Consequently, the bifurcation between surface-level recall and deep-seated misunderstanding was resolved through the intervention. The findings support the formal acceptance of the hypothesis, concluding that CTL is not merely a supplementary tool but a transformative instructional strategy capable of overcoming the cognitive hurdles to abstract chemical literacy in the Integrated Islamic High School environment.

Discussion

The data indicating a pre-test mean of 49.67 reflect the socio-environmental pressures inherent in the "Integrated Islamic High School" (SMAIT) ecosystem. At SMA IT Nurul Fikri, the environment functions as a significant covariate, where the intensive institutional schedule, comprising religious recitations, communal routines, and extracurricular obligations, compromises the cognitive bandwidth required for abstract chemical synthesis.

Empirical studies on Indonesian pesantren-style boarding schools consistently document a correlation between rigid, high-density timetables and a decline in academic stamina. Specifically, longitudinal analyses of science education in residential settings have recorded a 20–30% attrition in standardised test scores among boarding students compared to their day-school counterparts. (Zhong et al., 2024). This performance gap is statistically attributed to "multitasking overload" and chronic sleep deprivation, both of which are documented precursors to cognitive fatigue and diminished intrinsic motivation. In the context of this study, the pre-test results empirically validate these trends; the high rate of total incomprehension (40%) and superficial engagement (50%) aligns with established data on how sleep-deprived learners resort to "low-effort" cognitive strategies, such as rote memorisation and verbatim rephrasing, rather than analytical processing.

Furthermore, the motivational deficit observed in this cohort intersects with a measurable socio-cultural bias. (Ghimire & Sharma Neupane, 2025). Empirical evidence suggests that in integrated environments where spiritual education is prioritised, a "perceived utility gap" often emerges between theological and secular studies. (Kotten et al., 2025). This devaluation of empirical rigour in favour of theological

proficiency creates a psychological barrier that impedes the acquisition of complex, multi-level representations in chemistry.

By identifying these environmental stressors as empirical predictors of academic underachievement, this study justifies the implementation of Contextual Teaching and Learning (CTL). The CTL framework acts as a necessary intervention to counteract these stressors; by making hydrocarbon concepts immediately applicable to the students' lived reality, the model reduces the "extraneous cognitive load" caused by the school's rigid schedule, thereby facilitating a statistically significant improvement in conceptual mastery (as evidenced by the post-test mean of 83.13) (Baidoo, 2023).

The conceptual deficit identified in this study, characterised by a pre-test mean of 49.67, mirrors the "pedagogical stagnation" documented in nationwide assessments of Indonesian science education. However, the impact is more destructive to the tripartite framework of chemical representation. (Talanquer, 2025).

In the theory of chemical triplets, the lack of laboratory infrastructure at SMA IT Nurul Fikri forces a cognitive "decoupling." While students in resource-rich environments can bridge macroscopic observations with symbolic notation, the cohort in this study remained "tethered to textbook abstractions." This finding extends the work of (Nicholus et al., 2023)who argued that problem-based learning could mitigate lab shortages in physics; however, the current data suggest that, for hydrocarbons, mere problem-solving is insufficient without the "contextual anchors" provided by CTL.

Furthermore, the "fragmented cognition" observed in 50% of participants who relied on verbatim rephrasing aligns with Schneider's (2025) observations on the misuse of statistics in Indonesian curricula, where rote memorisation serves as a defence mechanism against abstract complexity. However, this study identifies a unique contextual variable that Pangemanan's work did not fully explore: the "boarding school effect." While previous studies on general high schools attribute low chemistry proficiency to a lack of facilities, this research suggests that for Integrated Islamic High Schools (SMAIT), the facility deficit is compounded by the "cognitive fatigue" of a dual-curriculum schedule. This critical intersection suggests that the 25% reduction in chemistry proficiency reported in nationwide surveys may actually be an underestimate for the SMAIT sector.

Finally, while recent policy initiatives from the Ministry of Education champion digital simulations as a universal remedy, this study's results offer a critical counter-perspective. The qualitative evidence of "total incomprehension" (40%) suggests that virtual labs may fail to engage if they do not incorporate the culturally responsive, tangible connections inherent in the CTL model. By achieving a post-test mean of 83.13, this study provides empirical evidence that CTL outperforms traditional digital-only interventions by reclaiming student agency through real-world application. Consequently, this study moves beyond the "procedural recognition" noted by Ristanto et al. (2019). It demonstrates that contextualization is the superior catalyst for transforming passive reception into active, analytical synthesis in resource-constrained religious institutions.

The transition from a pre-test mean of 49.67 to a post-test mean of 83.13 provides empirical evidence of the efficacy of the CTL framework in navigating the abstract complexities of hydrocarbon chemistry. This significant gain is not merely a numerical increase but a reflection of how the seven pillars of CTL, Constructivism, Inquiry, Questioning, Learning Community, Modelling, Reflection, and Authentic Assessment, functioned to resolve specific cognitive deficits identified in the pre-intervention phase.

For the 40% of students who initially exhibited "total incomprehension," the Modelling and Learning Community components of CTL acted as the primary catalysts for conceptual change. By replacing textbook diagrams with tangible "contextual anchors," such as analysing the viscosity of motor oils or the combustion of palm oil-derived biodiesel (ethnochemistry), students engaged in Constructivism. They built new knowledge from their lived experiences as residents of a rural boarding school, rather than memorising isolated chemical formulas. This is evidenced by a qualitative shift in student responses, from verbatim rephrasing to analytical descriptions of carbon chain lengths in everyday products.

Furthermore, the "superficial engagement" (50%) noted in the pre-test was addressed through the Inquiry and Questioning phases of CTL. Instead of passive reception, students were tasked with investigating the structural isomers of the fuels in their immediate surroundings. This pedagogical shift forced a "representational translation" from macroscopic observation of fuel efficiency to microscopic understanding of molecular branching. The post-test mean of 83.13 indicates that this Authentic Learning environment successfully mitigated the "cognitive fatigue" associated with the school's rigid schedule by making the content personally relevant and intrinsically motivating.

Ultimately, integrating these findings with CTL theory suggests that the model's Reflection component is vital for long-term retention in Integrated Islamic High Schools. By allowing students to internalise the "spirit of inquiry" alongside their spiritual education, CTL bridges the gap between secular science and daily life. Future reforms should, therefore, scale this intervention by incorporating student journals as a form of Authentic Assessment, ensuring that the conceptual gains in hydrocarbon mastery are sustained beyond the immediate testing cycle and translated into lifelong scientific literacy.

Conclusion

Contextual Teaching and Learning (CTL) demonstrates significant potential to enhance students' conceptual understanding of hydrocarbons in Islamic Integrated High Schools, particularly by bridging theoretical chemical principles with observable, real-world phenomena like petroleum-derived products. This approach mitigates the challenges posed by limited laboratory facilities common in such institutions, enabling students to grasp abstract concepts such as molecular structures, reactions, and classifications of alkanes, alkenes, and alkynes through relatable, hands-on analogies rooted in everyday life. By linking invisible molecular dynamics to familiar experiences, such as fuel use or industrial applications, it cultivates a deeper, more interconnected understanding of hydrocarbon properties and behaviours, fostering self-regulated learning and laying the foundation for sustained scientific literacy in chemistry education.

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