CENDEKIA: Jurnal Ilmu Pengetahuan
Vol. 6, No. 4, Agustus-Oktober 2026
e-ISSN : 2774-4183 | p-ISSN : 2774-8030
Online Journal System : https://jurnalp4i.com/index.php/cendekia

STUDENTS' UNDERSTANDING OF ALKANES IN ORGANIC CHEMISTRY I: A CASE STUDY AT FEH-UNTL IN 2026

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Diterima: *29/09/2026*; Direvisi: *08/10/2026*; Diterbitkan: *17/102026*

ABSTRAK

Pengajaran dan pembelajaran Kimia Organik mengharuskan mahasiswa melampaui sekadar menghafal aturan dan mengembangkan pemahaman konseptual, keterampilan interpretasi, serta kemampuan menerapkan pengetahuan dalam berbagai situasi. Studi ini bertujuan menganalisis pemahaman mahasiswa semester keempat di Departemen Pengajaran Kimia, Fakultas Pendidikan dan Humaniora, Universitas Nasional Timor Lorosa'e (FEH-UNTL), mengenai konsep alkana, dengan perhatian khusus pada nomenklatur, identifikasi struktural, rumus molekuler, dan representasi garis ikatan. Studi ini dilakukan pada tahun 2026 dengan desain deskriptif yang mengintegrasikan data kuantitatif dan kualitatif yang diperoleh melalui tes tertulis, observasi, dan wawancara semi-terstruktur. Populasi terdiri dari 69 mahasiswa yang sebelumnya mempelajari kandungan alkana. Karena populasi kurang dari 100 mahasiswa, semua 69 mahasiswa dimasukkan menggunakan total sampel. Hasil tes tertulis menunjukkan indeks pemahaman rata-rata sebesar 75,01%, diklasifikasikan sebagai pemahaman baik menurut skala yang digunakan dalam studi. Dari tanggapan, 47,8% diklasifikasikan sebagai sangat baik, 31,0% sebagai cukup, dan 21,2% sebagai buruk. Temuan kualitatif menunjukkan bahwa siswa menggunakan tinjauan individu, interaksi dengan teman sebaya, dan sumber daya digital untuk mendukung pembelajaran mereka, meskipun kesulitan tetap ada dalam nomenklatur dan interpretasi struktur tertentu. Disimpulkan bahwa siswa menunjukkan pemahaman konsep alkana yang umumnya baik, tetapi kesulitan spesifik dalam nomenklatur dan representasi struktural memerlukan penguatan lebih lanjut melalui aktivitas pembelajaran sistematis.

Kata kunci: kimia organik; alkana; pemahaman konseptual; pembelajaran; mahasiswa universitas; Timor-Leste

ABSTRACT

The teaching and learning of Organic Chemistry requires students to go beyond memorizing rules and develop conceptual understanding, interpretation skills, and the ability to apply knowledge in different situations. This study aimed to analyze the comprehension of fourth-semester students in the Department of Chemistry Teaching, Faculty of Education and Humanities, National University Timor Lorosa'e (FEH-UNTL), regarding alkane concepts, with particular attention to nomenclature, structural identification, molecular formulas, and bond-line representations. The study was conducted in 2026 using a descriptive design that integrated quantitative and qualitative data obtained through a written test, observation, and semi-structured interviews. The population consisted of 69 students who had previously studied the alkane content. Since the population comprised fewer than 100 students, all 69 students were included using total sampling. The results of the written test indicated an average comprehension index of 75.01%, classified as good comprehension according to the scale used in the study. Of the responses, 47.8% were classified as very good, 31.0% as sufficient, and 21.2% as poor. The qualitative findings indicated that students used individual review, peer interaction, and digital resources to support their learning, although

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https://doi.org/10.51878/cendekia.v6i4.16129

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Vol. 6, No. 4, Agustus-Oktober 2026
e-ISSN : 2774-4183 | p-ISSN : 2774-8030
Online Journal System : https://jurnalp4i.com/index.php/cendekia

difficulties persisted in nomenclature and the interpretation of certain structures. It is concluded that the students demonstrated generally good comprehension of alkane concepts, but specific difficulties in nomenclature and structural representation require further reinforcement through systematic learning activities.
Keywords: Organic Chemistry; alkanes; conceptual understanding; learning; university students; Timor-Leste.

INTRODUCTION

Education is a fundamental process for the development of knowledge, skills and critical capacity of individuals (Alves et al., 2021; Sajadi et al., 2024). In the context of higher education, scientific training is particularly relevant, as it prepares students to understand natural phenomena, solve problems and participate in a qualified way in professional and social life (Iyamuremye et al., 2025; Putica & Ralević, 2022). In the teaching of Chemistry, this purpose requires an articulation between conceptual knowledge, scientific procedures and the ability to interpret different representations of the subject (Cao & Cao, 2023).

Learning Chemistry is not reduced to the acquisition of definitions or the memorization of formulas (Barth et al., 2023; Hammer & Lewis, 2023). Scientific understanding presupposes that the student is able to interpret concepts, establish relationships between different knowledges, and apply what they have learned to new situations (Didham et al., 2024; Wamsler, 2020). Putica (2024) characterize conceptual understanding as the ability to understand, describe, and explain concepts through one's own formulations, going beyond simple memorization. Similarly, Purwanto (2021) highlight that conceptual understanding is essential for the student to use knowledge in depth in the analysis and resolution of problems.

This issue is particularly relevant in Organic Chemistry, a discipline that involves molecular structures, nomenclature, symbolic representations, and relationships between structure and properties. Alves et al. (2021) point out that students may have difficulties in establishing relationships between the contents of Organic Chemistry and other chemical concepts already studied, as well as in relating the contents to everyday situations. Moraes and DeGlopper, Schwarz, Ellias, & Stowe (2022) also highlight the complexity of chemical learning, associated, among other aspects, with the abstract nature of certain concepts and the need to move between different levels of representation.

In the subtheme of alkanes, comprehension involves knowledge about saturated hydrocarbons, molecular formulas, identification of the main chain, substituents, chain numbering, and application of nomenclature rules (Adu-Gyamfi & Asaki, 2022; Samiei Paghaleh & Rashtizadeh, 2026). Mastering these operations requires more than the recollection of isolated rules; it requires the ability to analyze the molecular structure and apply criteria in an articulated way. Thus, difficulties in identifying the main chain or assigning the numbering can compromise the correct construction of a compound's name (Kubisch et al., 2020; Zwolińska et al., 2022).

The analyzed study was carried out in the Department of Chemistry Teaching of FEH-UNTL and sought to identify the level of understanding of students of the IV semester on the alkane subtheme. The problem was built from the need to understand to what extent students master contents already studied and what difficulties still remain. The study also sought to relate the results obtained in the questionnaire with qualitative information from interviews and observations, allowing a more comprehensive reading of the investigated phenomenon.

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The general objective was to analyze the understanding of the students of the IV semester about Organic Chemistry, particularly about the alkane subtheme. Specifically, it sought to identify the level of understanding, verify the percentage distribution of the answers and qualitatively describe the experiences, difficulties and learning strategies of the participants. The relevance of the study lies in the possibility of providing elements to improve pedagogical practices in the teaching of Organic Chemistry and to support future research in the context of the training of Chemistry teachers in Timor-Leste.

METHODS

This study employed a descriptive design integrating quantitative and qualitative procedures. Quantitative data were obtained through a written test to assess students' comprehension of alkane concepts, while qualitative data were obtained through observation and semi-structured interviews. The integration of these data was used to describe students' comprehension and explore their learning experiences and difficulties. Qualitative data were analyzed using the Miles and Huberman procedures of data reduction, data display, and conclusion drawing (Miles & Huberman, 1994).

The study was conducted at the Department of Chemistry Teaching, Faculty of Education and Humanities, National University Timor Lorosa'e. Data collection took place on September 9, 2026, and interviews were conducted on September 15, 2026. The population comprised 69 fourth-semester students who had studied Organic Chemistry, particularly alkanes. Since the population was fewer than 100 students, all participants were included using total sampling, resulting in 69 students (49 female and 20 male).

Permission to conduct the study was obtained from the Faculty of Education and Humanities, National University Timor Lorosa'e. Before data collection, students were informed about the study and invited to participate voluntarily. No formal institutional ethical approval was obtained.

Data were collected using a self-developed written test, observation sheet, semi-structured interview guide, and documentation. All instruments were developed based on the learning objectives and indicators of alkane comprehension and were reviewed and validated by a lecturer. The written test consisted of ten items covering bond-line structures, prefixes and suffixes, isoalkane designation, hydrogen removal, nomenclature, molecular formulas, and bond-line structures. Test scores were classified as very good (81–100%), good (61–80%), sufficient (41–60%), poor (21–40%), and very poor (0–20%). Based on the test results, three students were purposively selected for interviews, representing high, medium, and low comprehension levels.

Quantitative data were analyzed using frequencies and percentages with the formula $P = F/N \times 100$, where P is the percentage, F is the frequency, and N is the number of participants. Observation and interview data were analyzed through data reduction, categorization, and thematic interpretation. The findings from the different data sources were compared to support the interpretation.

RESULTS AND DISCUSSION

Results

Sample Profile

A total of 69 fourth-semester students from the Department of Chemistry Teaching participated in the study. The participants consisted of 49 female students (72%) and 20 male

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students (28%). All participants had previously studied Organic Chemistry content related to alkanes. Therefore, the questionnaire assessed students' understanding of previously learned material rather than content that had not yet been introduced.

Overall Questionnaire Performance

The questionnaire results showed an overall comprehension index of 75.01%, which was classified as good comprehension according to the classification adopted in the study. The aggregate distribution across the ten items showed that 47.8% of responses were categorized as very good comprehension, 31.0% as sufficient comprehension, and 21.2% as poor comprehension. No responses were recorded in the good or very poor comprehension categories.

Although the overall index was classified as good, the distribution indicates variation in students' performance across the questionnaire items. The presence of 21.2% of responses in the poor comprehension category indicates that some aspects of alkane-related content remained difficult for the participants.

Comprehension by Indicator

The distribution of students' comprehension across the ten indicators is presented in Table 1.

Table 1. Students' Comprehension by Alkane Learning Indicator

Indicator	Very Good (%)	Sufficient (%)	Poor (%)
Bond-line connection	43.0	41.0	16.0
Prefixes and suffixes	72.5	13.0	14.5
Isoalkane designation	30.4	24.6	45.0
Hydrogen removal	27.5	23.2	49.3
Nomenclature of compounds (Item 5)	34.8	63.8	1.4
Nomenclature of compounds (Item 6)	65.2	34.8	0
Nomenclature of compounds (Item 7)	63.8	36.2	0
Molecular formula	68.1	0	31.9
Bond-line structure (Item 9)	5.8	53.6	40.6
Bond-line structure (Item 10)	66.7	20.3	13.0

Source: Author's elaboration based on the data presented in the original document.

The highest proportion of very good comprehension was observed for prefixes and suffixes (72.5%), followed by molecular formula (68.1%), bond-line structure in Item 10 (66.7%), nomenclature in Item 6 (65.2%), and nomenclature in Item 7 (63.8%).

The largest proportions of poor comprehension were found for hydrogen removal (49.3%) and isoalkane designation (45.0%). Bond-line structure in Item 9 also showed a relatively high proportion of poor comprehension (40.6%), while molecular formula had 31.9% of responses in the poor category.

Qualitative Findings

Interviews were conducted with three students representing high, medium, and low levels of questionnaire comprehension. The participants reported that understanding alkane-related material was influenced by the regularity of their study and review activities. Students

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generally perceived the material as more understandable when they paid attention during class and reviewed the material afterward.

Individual review was identified as one of the strategies used by participants. Students reported reviewing materials at home, discussing difficult topics with classmates, and using YouTube videos to clarify concepts that had not been fully understood during classroom instruction. Peer interaction was also reported as a learning support. Students indicated that they consulted classmates when they encountered difficulties. The participants further described the learning environment as relatively safe and conducive to interaction and concentration.

Discussion

Overall Understanding of Alkane Concepts

The overall comprehension index of 75.01% indicates that the students demonstrated a generally good understanding of alkane-related content. However, the distribution of responses shows that this understanding was not uniform across all aspects of the material. The presence of 21.2% of responses in the poor comprehension category indicates that satisfactory overall performance can coexist with difficulties in particular concepts.

This pattern can be explained by the representational demands of organic chemistry. Students are required to coordinate molecular formulas, structural formulas, skeletal representations, and nomenclature rather than simply recall isolated rules. Recent research has shown that students can experience difficulties when working with different chemical representations and when translating between representational forms. Schuessler et al. (2024) for example, reported difficulties among organic chemistry students when working with skeletal formulas and switching between representation formats. Similarly, Crowder et al. (2025) emphasized that representational competence is an important component of success in postsecondary organic chemistry.

This indicates that the overall comprehension index should be interpreted together with performance on individual indicators rather than as evidence of complete mastery. The findings therefore suggest that the students had established a general foundation in alkane concepts, but some structural and transformation-related aspects require further reinforcement.

Differences Across Comprehension Indicators

The strongest performance was observed in prefixes and suffixes, with 72.5% of responses classified as very good. The nomenclature indicators in Items 6 and 7 also showed relatively high levels of very good comprehension. These findings suggest that students were comparatively successful when applying naming conventions associated with established rules.

In contrast, isoalkane designation and hydrogen removal produced the highest proportions of poor comprehension. The results indicate that students experienced greater difficulty when they were required to interpret structural relationships or apply chemical rules to specific structural situations. A similar pattern was observed for the bond-line structure in Item 9, where only 5.8% of responses were categorized as very good and 40.6% as poor.

These differences suggest that familiarity with nomenclature rules does not necessarily translate into equivalent mastery of structural interpretation. Students must connect molecular formulas, structural representations, substituent positions, and nomenclature conventions. Schuessler et al. (2024) found that students' performance can be affected by the representation format used when drawing molecules from IUPAC names, highlighting the cognitive demands associated with skeletal representations. Silva & Sasseron (2025) likewise emphasized that

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e-ISSN : 2774-4183 | p-ISSN : 2774-8030
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visual representations can function as important tools for constructing and communicating knowledge in organic chemistry.

The difficulty observed in bond-line structures may therefore reflect the need to coordinate chemical rules with visual and structural reasoning. This interpretation is also supported by Marchak et al. (2026), who identified visual literacy and visual thinking as important components of undergraduate organic chemistry learning and reported that students can struggle with visual translations required for understanding organic chemistry concepts.

Learning Strategies and Student Difficulties

The interview findings indicate that students perceived regular study and review as important for understanding the material. Participants described reviewing lessons at home, consulting classmates, and using online videos when classroom explanations were insufficient. These responses suggest that students did not rely exclusively on classroom instruction when attempting to address conceptual difficulties.

The reported habit of reviewing material is consistent with recent research on study approaches in chemistry. Carpenter & Hodges (2024) reported that spaced practice can support mastery and retention in chemistry learning, providing a basis for understanding why repeated review may be perceived by students as useful.

Peer discussion was also reported as a strategy used when students encountered difficulties. Such interaction may provide opportunities to compare interpretations and clarify concepts. Recent research on peer-assisted learning in undergraduate organic chemistry found that sustained peer support was associated with better course performance, although the present study does not establish a causal relationship between peer discussion and students' comprehension.

The use of digital resources, particularly online videos, also indicates that students sought additional materials to reinforce classroom learning. Research on multimedia-supported learning in organic chemistry has reported positive potential for supporting students' conceptual mastery and engagement. Nsabayezu et al. (2025), for example, examined a multimedia-supported flipped classroom approach and found differences in conceptual mastery alongside positive student perspectives toward the approach. However, the present qualitative findings do not demonstrate that online videos directly improved students' comprehension. They are therefore better interpreted as learning resources that students reported using to address perceived difficulties.

Integration of Quantitative and Qualitative Findings

The quantitative and qualitative findings provide complementary evidence regarding students' understanding. The written test identified a generally good level of comprehension while revealing specific difficulties, particularly in hydrogen removal, isoalkane designation, and one bond-line structure item. The interviews provided contextual information about how students approached these difficulties through review, peer consultation, and digital learning resources.

The combined findings also indicate that comprehension is not necessarily uniform across all components of organic chemistry. A student may demonstrate stronger performance in nomenclature while experiencing difficulties with structural interpretation. This distinction is important because representational competence involves the ability to use and reason across multiple forms of chemical representation rather than simply recall chemical terminology.

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Crowder et al. (2025) similarly highlighted the importance of representational competence in relation to examination performance in postsecondary organic chemistry.

From a pedagogical perspective, the findings suggest the importance of learning activities that explicitly connect nomenclature rules with structural representations. Exercises involving main-chain identification, numbering, substituent recognition, bond-line interpretation, and systematic name construction may help students strengthen the relationship between symbolic rules and molecular structures. Recent work on guided drawing and visual-literacy interventions suggests that structured activities focused on chemical representations can support the development of students' representational and visual skills.

Study Limitations

Several limitations should be considered when interpreting the findings. First, the participants had already studied the alkane-related material; therefore, the study assessed previously learned knowledge rather than learning immediately following instruction. Differences in the extent and recency of students' prior learning may have influenced their test performance. Second, the qualitative component involved only three students selected according to their comprehension levels. Although their experiences provide contextual information about learning strategies and difficulties, the findings cannot be considered representative of all 69 participants.

The quantitative and qualitative components served different purposes. The percentages describe the distribution of test performance, whereas the interviews provide contextual information about students' experiences and learning strategies. Therefore, the qualitative findings should complement rather than statistically generalize the quantitative results. The findings should also be interpreted as descriptive evidence of students' comprehension and reported learning strategies rather than as evidence of the effectiveness of any particular learning intervention.

CONCLUSION

This study found that fourth-semester students of the Department of Chemistry Teaching, FEH-UNTL, demonstrated generally good comprehension of alkane concepts, with an overall comprehension index of 75.01%. However, comprehension varied across indicators. Students performed better in prefixes and suffixes and several nomenclature tasks, while greater difficulties were identified in isoalkane designation, hydrogen removal, and bond-line representation. The qualitative findings further indicated that students used individual review, peer support, and digital resources to support their learning.

Future research should involve a larger number of qualitative participants and examine changes in students' comprehension over a longer period. Comparative studies before and after specific instructional interventions focused on nomenclature and structural representation are also recommended to identify teaching approaches that can address the difficulties identified in this study.

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Vol. 6, No. 4, Agustus-Oktober 2026
e-ISSN : 2774-4183 | p-ISSN : 2774-8030
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https://doi.org/10.51878/cendekia.v6i4.16129

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Vol. 6, No. 4, Agustus-Oktober 2026
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