AlifChem Kit: A Recycled Plastic-Based 3D Learning Tool for Visualizing and Drawing Organic Skeletal Structures

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ABSTRACT

Organic chemistry is one of the challenging subjects in chemistry. The subject requires students to understand and visualize the molecular structures of compounds that cannot be seen directly. One of the common difficulties is learning to draw and skeletal structures and to identify the IUPAC name of the chemical compounds. Most of the students struggle to relate this two-dimensional skeletal formula with the real three-dimensional arrangement of atoms and bonds. This leads to misunderstanding and cause problems grasping in organic chemistry concepts. Due of this, AlifChem Kit was created developed and introduce as a teaching and learning tool that helps students visualize organic molecular structures through hand-on activities. The kit contains three-dimensional (3D) molecular models made from recycled plastic materials, making it both eco-friendly and affordable. With this Kit, students can explore carbon chains, identify bonding patterns, and gain a better understanding of how molecular are shown in skeletal formulas by physically handling and manipulating the models. The AlifChem kit also promotes active learning as the students can learn through observations, discussion, and exploration rather than just relying on textbook drawings. This hands-on experience improves their visual-spatial skills and builds confidence in accurately drawing and interpreting skeletal structures. At the same time, the use of recycled plastic materials encourages sustainability and environmental awareness in education. Ultimately, the AlifChem Kit offers suggest a practical and engaging learning experience that helps students master key concepts in organic chemistry. This innovation can improve students' understanding of skeletal structures, boost classroom engagement, and enhance learning outcomes while supporting sustainable education efforts.

Keywords: Organic Chemistry Education, Skeletal Structures, Molecular Visualization, 3D Learning Tool, Sustainable Education, Recycled Plastic Materials

INTRODUCTION

Generally, organic chemistry is a core subject in chemistry education, however many students find it difficult to understanding and learn. Unlike topics that can be directly observed, organic chemistry requires students to be more imagine and understand the arrangement of atoms and bond within molecules. Moreover, this can be challenging because molecular structure is often represented using symbols, formulas and diagram rather than physical objects. Among these represented, skeletal formula or structures are commonly used to simplify the drawing of organic compounds. Though students often struggle to understand what this skeletal formula and how there relate to the actual three-dimensional structure of molecules (Sánchez Morales et al., 2024). According to Underwood et al. (2021), many students experiences in visualizing molecular structures and accurately drawing skeletal formula and this actually affect their overall understanding of organic chemistry concept. Besides that, in most classrooms, learning is often supported by textbook illustrations and two-dimensional diagram. This usually may not be sufficient for students to visualize the actual three-dimensional arrangement of atoms and bond within a molecule (Hoai, 2023). As the result, students often struggle to connect ehat they see on paper with a real molecular structure and this making it more difficult for them to

interpret skeletal formula correctly. It also reported by Elvasova, (2025), these challenges can lead to misconceptions and hinder students' understanding of fundamental organic chemistry concepts.

Recognizing these challenges, the AlifChem Kit was develop as an innovative teaching and learning tool to enhance students' understanding of organic skeletal structures through visualization and hand -on learning. Moreover, the kit can be used by the students to interact directly with three-dimensional (3D) molecular models and helping them connect molecular structures with their corresponding skeletal representation. With this, student able transforming abstract concepts into tangible learning experiences. At the same time could promotes active engagement and improves students' confidence in interpreting and drawing skeletal formulas. Furthermore, the use of recycled plastic materials reflects a commitment to sustainable educational practices by reducing waste and providing an affordable teaching resource.

LITERATURE REVIEW

Challenges in Learning Organic Chemistry

Organic chemistry is often challenging for students because it requires them to understand concepts that cannot be directly observed. In a related study by Adrienne and Daniel (2024), students must connect macroscopic, sub microscopic, and symbolic representations to develop meaningful understanding. However, may learners struggle to interpret skeletal structures, which require them to visualize complete molecular arrangements from simplified representations. Besides that, Ward et al. (2026) also had reported that students that often face difficulties translating between skeletal formulas and three-dimensional molecular structures, resulting in misconceptions and weak conceptual understanding.

Molecular Visualization and Hands-on Learning in Chemistry Education

Molecular visualization is essential in helping students understand abstract organic chemistry concepts. According to Elyasova, (2025), physical molecular models often allowing the students to explore molecular structure, improve spatial reasoning skills, and strengthen their ability to interpret different chemical representation. Recent studies by Hoai, (2023) and Ward et al. (2026), had shown three-dimensional molecular models can improve students' representational competence and conceptual understanding. Therefore, visualization tools such as Alif Chem Kit considered as valuable resources for learning organic chemistry as it consistent with constructivist learning theory, hand-on learning which encourage students to actively construct knowledge through exploration and interaction.

Sustainability in Education

Generally, the use or recycled materials in educational resources promotes sustainability and also providing meaningful learning experiences (Sánchez Morales et al., 2024). In addition, sustainable teaching innovations help reduce waste, lower cost and encourage environmental awareness among students. These practices also support the efficient use of resources, minimize the environmental impacts of educational activities, and foster responsible consumption habits. Furthermore, sustainability-based learning encourages creativity, critical thinking, and problem-solving skills as students learn to repurpose materials and develop innovative solutions to real-world environmental challenges.

DISCUSSION

The AlifChem Kit is an innovative learning tool that enables students to better visualize and understand organic skeletal structures through active and hand-on learning. The kit designed to overcome the difficulties often faced by students in understanding and drawing skeletal formula in organic chemistry. According to Ward et al. (2026), many of students struggle to convert two-dimensional representation into three-dimensional molecular structures and this resulting in misconceptions and poor understanding of molecular connectivity and bonding arrangements.

Besides that, the kit consists of 3D molecular models which representing common aliphatic hydrocarbon structures in organic chemistry. These models are constructed using recycled plastic materials as shown in Figure 1 which making the kit environmentally friendly, cost-effective, and sustainable. In addition, the use of recycled materials not only reduces waste but also promotes environmental awareness among student and this eventually supporting sustainable educational practices. Besides that, students also can interact directly with the models by assembling, observing, and manipulating the molecular structures. With this process, students can identify carbon chains, branching patterns, and bonding arrangements with more effectively than through conventional textbook illustrations alone. In addition, these physical models enable students to visualize the spatial arrangement of atoms in chemical compound and can understand how three-dimensional molecular structures are represented as skeletal formula.

Furthermore, the AlifChem Kit (Figure 1) also supports active and student learning by encouraging them in exploration, discussion, and collaborative in problem-solving. Through this process, students are given opportunities to construct molecular structures and then translate them into skeletal representations. This can strengthen their visual-spatial skills and conceptual understanding in subject of organic chemistry. By bridging the gap between abstract molecular concepts and physical learning experiences, this kit eventually helps students develop confidence in drawing and interpreting skeletal structures accurately.

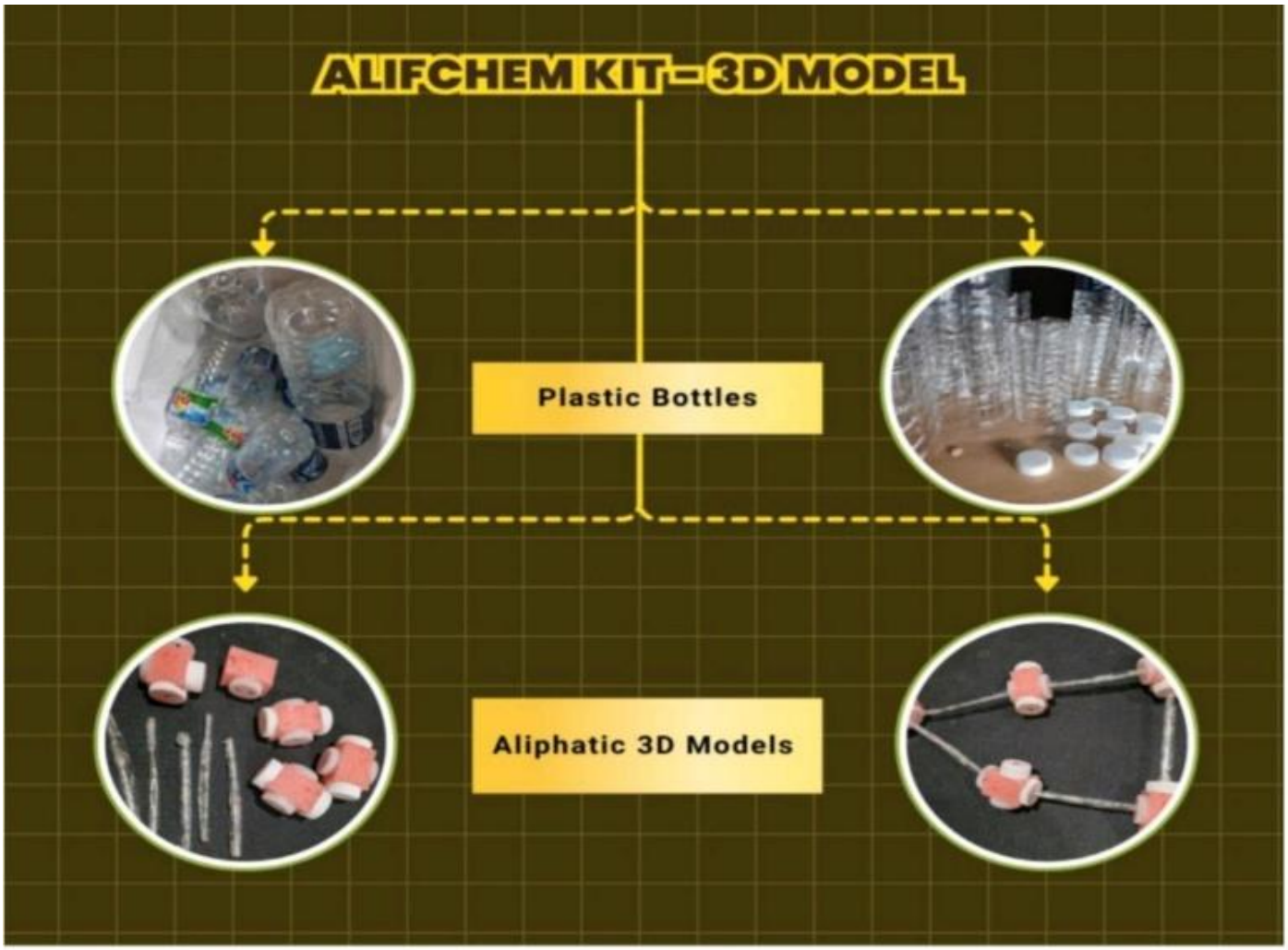

Figure 1. AlifChem Kit constructed from recycled plastic materials for visualizing and learning organic skeletal structures.

Figure 2 show the conceptual framework of the AlifChem Kit learning process. The framework suggest that students will first interact with the 3D molecular models, which allowing them to develop their visualization skills. This not only contribute to a better understanding of skeletal structures but also enable for them to draw

and interpret skeletal formulas more accurately. This also supported by Hoai, (2023), who found that visualization could supports a deeper understanding by transforming abstract into concrete representations.

3D Molecular Models
↓
Visualization Skills
↓
Understanding of Skeletal Structures
↓
Ability to Draw Skeletal Formulas Accurately

Figure 2. Conceptual Framework of AlifChem Kit Learning Process

Moreover, the kit also supports active learning by encouraging students to discuss, explore, and explain molecular structures collaboratively. These interactions eventually promote deeper understanding and improve students' confidence in drawing skeletal structure accurately. Furthermore, the use of recycled plastic materials demonstrates that effective educational tools can be developed sustainably and at low cost. From an educational perspective, the AlifChem Kit aligns with constructivist learning principles by enabling students to learn through experience and discovery. At the same time, it also addresses different learning styles, particularly on visual and kinesthetic learners who benefit from hand-on activities. In addition, this innovation could contribute to SDG 4: Quality Education and SDG 12: Responsible consumption and production by promoting inclusive learning and reuse of plastic materials.

RECOMMENDATION

Future research should evaluate the effectiveness of the AlifChem Kit through experimental studies involving pre-test and post-test assessments, student feedback surveys, and comparisons with traditional teaching approaches. The Kit may also can be expanded organic chemistry concepts such as stereochemistry, functional group transformations, and reaction mechanisms. In addition, its applicability across different educational levels and learning environments should be investigated. Beside that, an improvement to the kit's design, durable and customizable components could be enhanced its long-term use in during the lecture.

CONCLUSION

AlifChem kit is an innovative and sustainable teaching tools that made from recycled plastic materials which enables students to visualise, understand and draw organic skeletal structures through hand -on learning. This kit not just only enhances students' visual spatial skills, but together with the understanding and engagement in organic chemistry. In addition, the use of recycled materials promotes environmental sustainability and supports responsible resource utilization. Overall, the AlifChem Kit strong potential to improve the teaching and learning of organic chemistry while encouraging educational practices.

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