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Application of digital media and deep learning to hydrocarbon materials at the high school level: Systematic literature review

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Abstract

This study aims to analyze the use of digital media and deep learning learning on hydrocarbon materials and their derivative compounds at the high school level through the Systematic Literature Review (SLR) approach. The study was conducted by analyzing various journals from Scopus and Google Scholar data using the keywords "digital media", "deep learning", "hydrocarbon compounds", "SMA", and "Indonesia". Of the 127 articles found between 2010–2025, only five met the inclusion criteria, namely research conducted in Indonesia using quantitative methods in the context of high school chemistry learning. The analysis shows that the use of digital media such as interactive simulations, animated videos, and games significantly improves student learning outcomes and motivation. In addition, the deep learning approach also contributes to improving students' critical and analytical thinking skills, although its implementation is still hampered by infrastructure problems and teacher readiness. Overall, digital media and deep learning have proven to be effective in improving students' conceptual understanding and engagement in chemistry learning. This study recommends the development of an interactive digital media-based learning model with a deep learning approach to evaluate its effectiveness in the long term.

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INTRODUCTION

Hydrocarbon compound material is one of the important topics in chemistry learning at the high school level. Mastery of this concept is needed to understand various chemical phenomena and their applications in daily life. However, student learning outcomes in this material still show limitations due to the lack of visualization and interactivity in traditional learning (Sutrisno et al., 2020).

Hydrocarbon compound material is one of the important topics in the high school chemistry curriculum that is often considered difficult by students due to its abstract and complex nature. The material requires an understanding of structure, functional groups, reactions, and applications. Therefore, the development of interactive learning media is very necessary to help students understand these concepts more deeply. With the development of digital technology, digital media such as simulation applications and deep learning (DL) can be innovative solutions in learning. Deep learning in the context of education refers to a learning approach that allows students to learn through complex patterns, such as automatic recognition of molecular structures.

The development of digital technology and the pressure on 21st century learning encourage teachers to utilize digital media in the chemistry learning process. Chemistry learning in the digital era requires innovation in the delivery of material to be more interesting and easy for students to understand. One of the innovations that is developing is the use of interactive digital media as a learning medium. Digital media provides a wide variety of resources to deepen understanding, facts, and concepts taught. By utilizing technology, the learning and teaching process of students becomes more interesting, interactive, and in accordance with the needs of the times (Kuntari, 2023).

Interactive digital media can increase student engagement through multimedia features, interactive quizzes, and attractive displays so that it is expected to increase motivation and understanding of chemical concepts more effectively (Santoso & Dewi, 2021). Interactive learning technology can be a solution to increase student engagement. According to Setiawan et al. (2023), the use of interactive learning media in chemistry learning can significantly increase student motivation and learning outcomes by enabling the presentation of videos, animations, and interactive quizzes that support student-focused deep learning-based learning.

This research seeks to answer the research gap in the development of digital media in chemical learning, especially hydrocarbon compounds which are still focused on product development and technological aspects alone but have not emphasized the application of deep learning learning strategies. In fact, deep learning requires a systematic learning design by measuring the improvement of critical, analytical, and reflective thinking skills. Thus, this study was conducted to map the extent to which digital media has been utilized in the context of chemical learning in Indonesia and analyze the effectiveness of deep learning.

METHOD

This study uses the Systematic Literature Review (SLR) method with the aim of examining the results of research systematically and objectively that are relevant to the topic. This method is carried out by identifying, reviewing, evaluating, and interpreting all available research. The researcher reviews articles that are relevant to the topic. The review process is carried out systematically and structured in each process by following predetermined stages (Triandini et al., 2019). Then, the researcher conducted an in-depth study of the article that had been reviewed. The Systematic Literature Review technique is carried out in five stages, namely: (1) making a formulation of the research question, (2) mapping and searching for articles that are in accordance with the research questions asked, (3) including / classification and exclusion/evaluation by selecting the articles that have been collected, (4) presenting and processing data, (5) interpreting the findings in the article and ending in the drawing of conclusions (Nurfadilah et al., 2022).

The first step taken by the researcher is to determine the theme to be studied. The researcher took the theme "digital media and deep learning" as the topic to be used in the research. Literature searches were carried out through various journals with the keywords "digital media", "deep learning", "hydrocarbon compounds", "high school", "Indonesia". Based on the results of journal searches on Scopus and Google Scholar, researchers found 127 articles published in 2010-2025. After filtering based on titles and abstracts, 5 articles that met the criteria were obtained.

The researcher sets the inclusion and exclusion criteria, which are:

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion criteria
The research was conducted in Indonesia	The research was not conducted in Indonesia
Hydrocarbon learning materials	Matter is not a hydrocarbon compound
At the high school/MA level	Not at the high school/MA level
Using interactive digital media in learning	Using conventional learning

Table 2. Journal Search Process

Stages	Number of articles	Information
Early identification of Scopus and google scholar	127	Search results with the main keyword
Filtering by title and abstract	15	Articles relevant to the specified topic
Extraction according to the criteria	5	Articles that meet the inclusion criteria

FINDINGS AND DISCUSSION

Digital media such as interactive simulation apps allow students to see and understand difficult concepts more clearly. This reduces the abstract nature that is often a barrier in learning chemistry. In addition, the use of DL in learning facilitates students to learn independently, develop critical thinking skills, and increase motivation to learn.

Based on the results of literature search from the Scopus database and Google Scholar using the SLR method, five articles were obtained that met the inclusion criteria that had been set, namely research conducted in Indonesia at the high school level with the topic of learning hydrocarbon compounds using digital media and deep learning approaches.

Table 2. Journal Results

No	Name of researcher and citation	Research title	Digital Media	Method	Results and types of statistical tests	Conclusion
1	Fitriani *et al* (2020)	Development of Interactive Learing Media using Autoplay Studio 8 for Hydrocarbon Material of Class XI Senior High School	Interactive learning media using the Autoplay Studio 8 application.	R&D	The media is stated to be very valid by experts. The average percentage of media experts is 94.15% and material experts are 93.7% with teacher responses of 94.6% and student responses of 92.33%, showing that the category is very practical and very interesting	Interactive learning media based on Autoplay Studio 8 for hydrocarbon meters for class XI SMA/MA is valid and practical and ready to be used in learning so it is recommended for the learning process of hydrocarbon materials.
2	Zhafirah *et al* (2020)	Development of Hydrocarbon PBL E-Module	Flipbook Maker	R&D model 4-D	High validity (85-97%), indicates excellent practicality	The media is feasible and practical to use for hydrocarbon learning in high school
3	Sari *et al* (2021)	Developing Student's Conceptual Understanding and Critical Thingking Through *Dunia Hidrokarbon* Games	Game Computer	R&D (limited trial)	Understanding the basic concepts remembers,	Games are effective for conveying basic concepts and enhancing students' critical thinking.
4	Zulyati *et al* (2022)	Application of Problem-Based Worksheet on Hydrocarbon	Problem based worksheet	Quantitative One Group Pretest-	The analysis of learning outcomes showed an increase in the average score	The application of Problem-Based Worksheet to hydrocarbon

No	Name of researcher and citation	Research title	Digital Media	Method	Results and types of statistical tests	Conclusion
		Combustion Materials through E-Learning to Enhance Student's Learning Outcomes and Enviromental Care Attitude		Posttest Design with a sample of 29 students of grade XI MIPA at SMA N 3 Banda Aceh	from 43.10 to 71.50. There is a significant difference in the results of the study. In addition, there was an increase in environmental care from 62.54 to 79.95.	combustion materials through E-Learning can improve learning outcomes and students' attitude of caring for the environment.
5	Enawaty *et al* (2025)	Development of Digital Literacy Based Game Cards on Hydrocarbon Material	Hy-Card Digital Literacy	ADDIE R&D model	Material validation is 98%, and gets student responses of 85-89%	Digital media in the form of digital game cards is very suitable to use and attracts students' interest in learning hydrocarbons.

The results of the analysis show that the research method used is Research and Development (R&D) and quantitative one group pretest-post test design. R&D is used to design, improve, and validate products to improve the quality of learning (Gafur *et al*., 2025). R&D is here to create innovation and problem-solving in the education system. Based on the analysis and adjustment to the inclusion criteria, the discussion of the article was obtained as follows:

1. **Fitriani O., Susilawati., Linda R. (2020)** developing interactive learning media using the Autoplay Studio 8 application. This application is used because it is able to combine text, images, audio, video, and 3D animations to visualize the structure of hydrocarbon compounds. The media is stated to be very valid by experts. The average percentage of media experts is 94.15% and material experts are 93.7% with teacher responses of 94.6% and student responses of 92.33% showing very practical and very interesting categories. This media was developed to overcome students' difficulties in understanding abstract hydrocarbon concepts and the limitations of conventional two-pronged approaches such as Powerpoint which tend to make learning teacher centered. This media is able to present 3D structural animations so that information becomes more realistic and clear. The conclusion obtained is that the interactive learning media based on Autoplay Studio 8 for hydrocarbon material for class XI SMA/MA is valid and practical to use so it is recommended for the learning process.
2. **Zhafurah *et al*. (2020)** developing hydrocarbon e-modules using the Kvisoft Flipbook Maker application. This e-module creates text, animation, video, and evaluation questions. The validity of the meter reached 85.39 and the validity of the media reached 97.02%, while the practicality of teachers and students in the use of this e-module was in the very good category. From these results, the conclusion was obtained that this media is effective in increasing student participation and learning independence.
3. **Sari *et al*. (2021) developed** a computer educational game called "Dunia Hidrokarbon". This game helps students understand the structure of formulas, and the nomenclature of alkanes, alkenes, and alkynes. The results of the study show a significant increase in the understanding of the basic concept of hydrocarbons, although the concept of isomers is still difficult for students to understand. This game also improves critical thinking skills in the aspect of focusing on problems and decision-making.
4. **Zulyati., Sulastri., Nurmalia C., Yusrizal., and Hasan. (2022)** conducting a quantitative test with one group pretest-posttest design. The sample used was 29 students in grade XI MIPA at

SMA N 3 Banda Aceh. The media used is E-Learning using Microsoft Office 365 / Microsoft Teams online application with the main instrument in the form of *a* Problem-Based Worksheet (Student Worksheet based on problems). The analysis of learning outcomes showed an increase in the average score from 43,10 to 71,50. There was a significant difference in teaching results based on the t-test (t_{count} 25.65 > t_{table} 1.65). In addition, there was an increase in environmental care from 62,54 to 79,95 which was good quality with an N-gain of 47.63 in the medium category. The improvement in learning outcomes and environmental care is caused by the implementation of problem-based LKPD through *e-learning* that is able to motivate students to think critically. Teaching becomes more interesting because students are active in identifying, analyzing, and solving problems related to daily life through group discussions. The application of problem-based worksheets on hydrocarbon combustion materials through *e-leaning* can improve learning outcomes and students' attitude of caring for the environment.

5. **Enawaty *et al*. (2025)** produced a "Hy-Card" game card media developed using BookCreator and Canva. Hy-Card integrates digital literacy, collaboration, and problem-solving. The product is categorized as very feasible with a meter validity of 98.5% and a user response of 85-89%. This medium is effective in overcoming hydrocarbon misconceptions and increasing students' motivation to learn.

Overall, these results show that the application of digital media and deep learning approaches have a positive impact on improving understanding of chemical concepts, learning motivation, and learning efficiency. However, the main challenges that still arise are the limited digital facilities in some regions and the low readiness of teachers in integrating technology into the learning process.

The results of the SLR analysis show that interactive digital media can overcome conceptual difficulties in abstract hydrocarbon materials. In addition, learning that uses digital media supports active and student-centered learning, where students are expected to actively explore concepts through interactive features. This encourages the high-level thinking process that is at the core of deep learning (Biggs & Tang, 2011). The deep learning approach in chemistry learning plays an important role in developing students' critical and analytical thinking skills. The five articles show that the integration of digital media with in-depth learning strategies can increase student motivation and engagement.

The SLR results of the five articles analyzed show that the use of digital media in chemistry learning, especially hydrocarbon materials, has great potential to improve students' concept understanding, learning motivation, and critical thinking skills. Digital media such as digital media based on Autoplay Studio 8 (Fitriani *et al.* 2020), PBL-based e-modules (Zhafirah *et al*., 2020), educational games in the "Dunia Hidrokarbon" (Sari *et al*., 2021), problem-based worksheets (Zulyati *et al*. 2022), and Hy-Card digital literacy (Enawaty et al., 2025) have proven to be able to strengthen the visualization of hydrocarbon concepts. Digital media is able to present animations, simulations, interactive quizzes, and challenge-based games so that hydrocarbon materials are easier to understand than conventional learning. In addition, digital media has proven to be able to create an interesting, collaborative, and encouraging learning environment so that students can interact with the content and materials presented through various visual and kinesthetic modes.

In the application of deep learning, the five articles that have been analyzed using multimedia-based digital media, simple interactive harvesting and 3D molecular visualization are part of the application of simple deep learning. However, the five articles have not integrated adaptive artificial intelligence (AI) models such as predicting misconceptions and automatically recommending materials. The main obstacle in the implementation of deep learning in Indonesia comes from the limitations of technological infrastructure and the readiness of teachers to integrate digital media in the teaching and learning process so that digital media still focuses on presenting content instead of analyzing student behavior. Therefore, education policy support, training for teachers, and the provision of adequate digital facilities are needed so that the implementation of deep learning-based chemistry learning can be carried out evenly and sustainably in all high schools in Indonesia.

Some research is still limited to the technological aspect and has not evaluated how deep learning can shape students' critical, analytical, and reflective thinking skills. Therefore, advanced quantitative research is needed that can clearly measure such skills using valid and reliable instruments. This indicates that although digital media and deep learning have great potential, equality of access is an important factor for successful implementation.

Overall, this study underscores the importance of developing learning models that integrate digital media with deep learning approaches, as well as the need for support in terms of infrastructure and training for teachers. The research recommendations also include long-term studies for a more in-depth evaluation of the effectiveness of this method. The Systematic Literature Review (SLR) shows that the application of digital media and deep learning learning in the teaching of hydrocarbon-derived compound materials at the high school level in Indonesia has yielded significant results. Of the five studies analyzed, most showed improvements in student learning outcomes measured through valid statistical tests.

CONCLUSION AND SUGGESTIONS

This SLR shows that the application of digital media and deep learning learning on hydrocarbon-derived compound materials in Indonesian high schools is effective in improving student understanding, with strong quantitative evidence through significant statistical tests. Digital media such as interactive simulations and deep learning through 3D visualization, games, and interactive quizzes improve visualization and concept accuracy, but infrastructure challenges and lack of development for deep learning.

Recommendation: Develop a hybrid learning model, integrate it with the national curriculum, and conduct long-term studies for continuous evaluation. This research contributes to the innovation of chemistry education in Indonesia, with the potential to improve the learning outcomes of high school students nationally. For further development, focusing on mixed methods and rural contexts can fill the identified research gaps.

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