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Enhancing Digital Literacy and Chemistry Conceptual Understanding Through Hybrid On-Site E-Learning (HoSEL) for Students

Florida Doloksaribu[1*], Albaiti[2], Irwandi Yogo Suaka[3], Rival Iriansyah[4]

[1,2,3]Chemical Education, Faculty of Teacher Training and Education, Universitas Cenderawasih, Indonesia
[4]Yayasan Darud Dakwah Wal-Irsyad Entrop Jayapura, Indonesia

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Corresponding Author:
Author Name*: Florida Doloksaribu
Email*: jfloridadoloks@gmail.com

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ABSTRACT

This study aims to improve students' understanding of chemical concepts and digital literacy through Hybrid On-Site E-Learning (HoSEL) with a focus on the structure, nomenclature, and applications of organic compounds. This type of research is mixed methods. The participants consisted of 38 eleventh-grade science students from MA DDI Jayapura, divided into control and experimental groups. The participants consisted of 38 students of grade XI IPA MA DDI Jayapura who were divided into control and experimental groups. The control group followed a conventional teaching model (without HoSEL), while the experimental group was taught using the HoSEL model. The research instrument used a test given at the beginning and end of learning. The analysis of the research data used inferential statistics and the N-Gain test. The results of the analysis showed that before the implementation of HoSEL, students' understanding of chemical concepts was already at a very good level, but their digital literacy achievements were still very low (0.12). After the implementation of HoSEL, there was a significant increase in both conceptual understanding and digital literacy ($p < 0.001$), which showed the effectiveness of the model, especially with high N-Gain on digital literacy (0.79). In addition, 85.5% of students responded positively to the use of the HoSEL model, making it a recommended approach for chemistry education, especially in the Papua region.

Keywords: digital literacy, chemical, concepts understanding, hybrid, on-site e-learning.

INTRODUCTION

The advancement of digital technology has brought significant transformation to various aspects of life, including education. In the Industrial Revolution 4.0 era, digital literacy has become an essential competency that both students and educators must master to optimize the learning process. However, in some regions of Indonesia, such as Madrasah Aliyah (MA) DDI Jayapura, access to technology for understanding scientific concepts particularly chemistry still faces numerous challenges. Low digital literacy and difficulties in grasping abstract chemical concepts may hinder the achievement of learning objectives. As is known, e-learning is an electronic/distance learning system that utilizes information technology to distribute learning materials to its users. This model emphasizes self-directed learning and has proven effective during the COVID-19 pandemic [1], [2]. During the e-learning process, students interact with educators through communication applications [3]. Chemistry e-learning employs virtual application media to enhance students' skills [4], [5], [6]. E-learning, which involves the implementation of electronic media such as e-modules and e-virtual tools, proves most effective when blended with other learning methods [7], [8].

Several chemistry topics taught via e-learning applications have been shown to improve conceptual understanding, virtual laboratory skills, interactive communication, and other chemistry learning processes [9], [10]. In many developed countries, digital-based learning systems have become an integral part of education, complementing on-site instruction. This approach is believed to enhance students' ability to access useful information independently. Positive feedback from learners should not be overlooked, as understanding e-learning systems can reduce uncertainty and improve engagement [11], [12].

Furthermore, e-learning can foster a sense of responsibility among students toward completing assigned tasks while also enabling them to access a vast breadth of knowledge. Some studies indicate that non-e-learning methods may reduce the quality of education [9], [13]. Analysis demonstrates that integrated e-learning enhances students' insights significantly [14], [15]. Given students' digital engagement, this should positively contribute to improving scientific and digital literacy by guiding them toward productive use, thereby minimizing negative effects.

Students with strong digital literacy can be more easily directed toward self-beneficial outcomes, such as enhanced learning quality [16]. Although digital learning is not equally effective in all disciplines compared to science, e-learning played a crucial role in sustaining education during the COVID-19 pandemic [17], [18]. E-learning literacy is an intellectual process involving discovery, consumption, and effective communication of information. Students must cultivate evaluative dispositions when navigating digital content. Critical thinking is essential for accurate interaction with online resources; otherwise, significant educational losses may occur [19].

Digital literacy has the potential to transform learners broadly among the Millennial/Generation Y or Net Generation. The characteristics of this group include confidence, team orientation, conventionality, stress, and high achievement. This generation is entering the workforce and driving digitally oriented change. Such transformation will continue as global internet users exceed 3 billion (42% of the population) and keep growing. Based on national populations, Canada has the highest internet access rate at 93%, while India has the lowest at 19% [20]. Additionally, despite governments providing widespread access, low economic status can still hinder digital literacy [21].

Defining digital literacy is highly complex. By 2020, researchers concluded that the concept encompasses technological competency, pedagogical skills, and strategic implementation. Digital literacy must be ingrained in students to enable active learning through the technology they use. Educators play a crucial role in guiding students toward positive self-development.

Based on observations in several high schools in Jayapura City, it appears that most have not yet utilized digital tools as part of learning. Some schools that have adopted e-learning only use it for basic communication, such as exchanging messages between teachers and students. In reality, internet access in Jayapura City is now very smooth, and students already use it for gaming, watching movies, YouTube, and other entertainment. However, the use of digital learning applications remains minimal, primarily due to the lack of encouragement for educators' digital literacy in utilizing the internet for teaching and learning activities [22].

Digital-based science learning using PhET simulations at the high school level has shown significant improvement compared to classes without PhET [23], [24]. Given this phenomenon, the demands, and the recommendations for learning in many regions of Indonesia especially Papua. It is necessary to analyze the effectiveness of e-learning facilities and educators' ability to utilize them in teaching. Many schools still prefer conventional learning because numerous educators do not feel left behind even when they do not understand or utilize digital learning applications. E-learning-based learning is highly needed in Papua, particularly due to frequent security disruptions caused by armed criminal groups (KKB). These incidents often instill fear in students and parents, leading to school closures. However, learning must continue.

RESEARCH METHODS

This study employs a mixed-method embedded design [25]. to analyze the assessment results of conceptual understanding and digital skills knowledge before and after implementing the HoSEL model. The evaluation of conceptual understanding was analyzed based on N-Gain scores and inferential statistical analysis. The participants consisted of 38 eleventh-grade science students from MA DDI Jayapura, divided into control and experimental groups. The control group followed the conventional teaching model (without HoSEL), while the experimental group was taught using the HoSEL model. The subject matter focused on chemical structures, nomenclature, and the applications of organic compounds, selected based on the curriculum taught during the semester. The qualitative data included observations, interviews, and student feedback to examine the actual conditions of chemistry learning and their responses after the HoSEL implementation. Meanwhile, the quantitative data comprised conceptual understanding scores from the control and experimental groups, measured through pretest-posttest scores (N-Gain), along with inferential statistical analysis.

The syntax of the HoSEL chemistry model was adapted to align with the subject characteristics, integrating E-learning and digital elements. Both conceptual understanding and E-learning skills were assessed using quantitative and qualitative data. The research design is illustrated in figure 1.

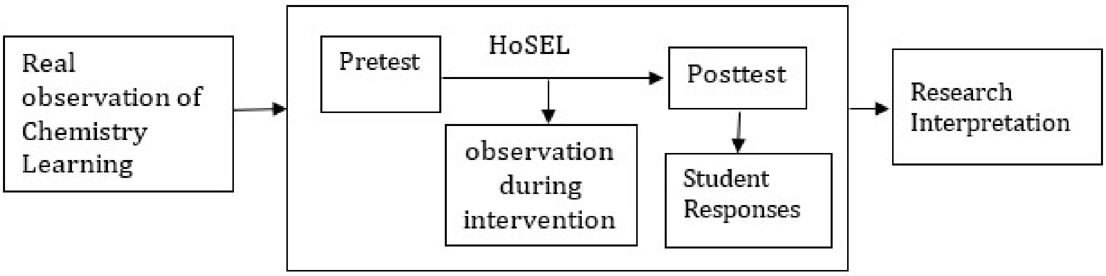

Figure 1. HoSEL based mixed methods research design

The pretest and posttest data on conceptual understanding and digital literacy were analyzed using N-Gain analysis and inferential statistical analysis through the SPSS-21 application. This was conducted to determine the effectiveness of the learning model used, both in the control group and the experimental group

RESULT AND DISCUSSION

The use of the HoSEL model in chemistry learning in the context of chemical structure material, nomenclature, and the use of organic compounds for different concepts can be illustrated in the Physical Education Technology (PhET) application, Chemskets and Vokoscreen, Canva, Zoom and others. This application can be used as part of chemistry learning in the form of virtual practicums, writing chemical reaction structure formulas, and vokoscreen presentation videos and so on. Some images of technology applications used in figure 2.

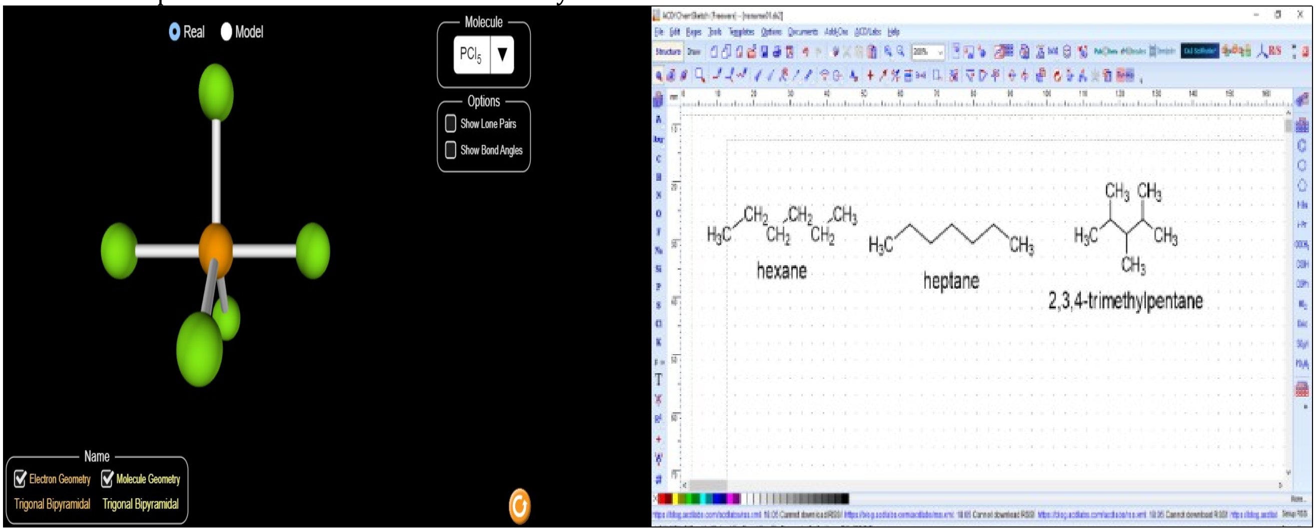

Figure 2. Application of PhET, Chemsket, and Vokoscreen in chemistry learning

To find out the real conditions of chemistry learning in class XI MA DDI Jayapura students, a questionnaire was distributed to obtain student responses to how current technology trend applications are used in chemistry learning. The context analyzed was based on whether students used the PhET application as part of a chemistry simulation, the chemsket application in describing the geometric structure of molecules, whatsapps as a communication medium for chemistry learning groups, google searching as a search for learning materials and assignments, learning videos as part of learning, electronic books and articles as reference sources, utilizing virtual chemistry practicums, using technology game applications in solving questions, utilizing google forms in solving questions, utilizing zoom or google meet in learning meetings, and using the PPT canva application in presenting assignments. All of these question contexts were given to students in the control and experimental classes. Briefly, the analysis of the observation results of the responses of students in the control and experimental classes is shown in table 1.

Table 1. Real observation results of technology utilization in chemistry E-learning

Group	**N**	**% Response Mean**	
		Positive	**Negative**
Control	19	22.5	77.5
Experiment	19	27.5	72.5

The results of real observations of the use of learning technology in both the control and experimental classes did not differ much, because positive responses to the use of technology applications were only 22.5% and 27.5%. Both groups prove the minimal use of technology applications in chemistry learning, so it must be a concern for teachers in the current era of advanced technology. The results of this data analysis are the basis for how the HoSEL model is expected to have an impact on subsequent chemistry learning. The result N-Gain of understanding concept and digital literacy shown in table 2.

Table 2. N-Gain Results

Aspect	**N**	**Pretest Mean**	**Posttest Mean**	**N-Gain Mean**	**N-Gain Category**
Conceptual Understanding	19	33.64	78.75	0.65	Medium
		14.47	82.63	0.78	High
Digital Literacy		14.74	24.21	0.126	low
		14.21	84.47	0.79	High

Based on the data in Table 2, the implementation of Hybrid On-Site E-Learning (HoSEL)-based e-learning shows a positive impact on improving students' conceptual understanding and digital literacy in chemistry learning. The conceptual aspect experienced an increase in average value from 33.64 (pretest) to

78.75 (posttest), with an N-Gain of 0.65, which is included in the moderate category for the control class. Meanwhile, the understanding aspect showed very good results with an N-Gain of 0.78 and is included in the high category, reflecting the effectiveness of the HoSEL approach in building students' understanding of the material in a deeper and more meaningful way in the experimental class. The combination of face-to-face and online learning in this model has been proven to enrich the learning experience and strengthen student engagement in chemistry material.

In the aspect of digital literacy, the control class score showed an N-Gain of 0.126 (low category), while the experimental class score showed a significant increase with an N-Gain of 0.79 (high category). This difference could be caused by differences in student groups or different stages of implementation. However, the highest results show that the HoSEL model is able to significantly improve students' digital literacy. This shows that direct integration of technology in the chemistry learning process can improve students' ability to use digital devices to obtain, process, and present information effectively, a competency that is very relevant in today's digital era. E-learning has been proven to improve digital literacy, as shown by students being able to actively and enthusiastically utilize existing technology to learn and access the information needed. The implementation of e-learning has provided benefits that allow students to use existing technology according to its function and usefulness [26].

Table 3. Inferential Analysis

Aspect	Shapiro-Wilk Test	Wilcoxon Signed-Rank Test	Effect Size
Conceptual Understanding	Control	P< 0.001	6.1
	Experiment		11.4
Digital Literacy	Control		0.88
	Experiment		2.1

Based on Table 3 containing the results of the inferential analysis, it was obtained that the significance value of the Wilcoxon Signed-Rank Test for conceptual understanding was at P <0.001, which indicates that there is a very significant difference between before and after the implementation of the Hybrid On-Site E-Learning (HoSEL) learning model. The effect size value for the experimental group was 11.4, much higher than the control group which was only 6.1. This confirms that the implementation of HoSEL has a significant impact on improving students' conceptual understanding of chemistry. This hybrid learning provides space for students to interact directly with teachers and explore materials through digital platforms independently, so that understanding becomes deeper and more structured.

In terms of digital literacy, the results of the Wilcoxon test showed the same significance (P <0.001) with an effect size of 2.1 for the experimental group and 0.88 for the control group. This shows that the increase in students' digital literacy in the group that took HoSEL learning was much greater than the control group. The effectiveness of HoSEL learning in this aspect cannot be separated from the direct involvement of students in technology-based activities such as the use of LMS, online learning resources, and digital assignments. Thus, HoSEL not only improves academic competencies such as understanding chemical concepts, but also strengthens 21st-century competencies such as digital literacy which are very much needed in modern life and learning. In order for innovative learning with e-learning to have a real impact on student learning outcomes, adaptation time is needed. In the learning process, e-learning can provide students with wider opportunities to be active in learning activities. Learning will be felt more meaningful if students can build knowledge that connects the real world with learning materials [27].

CONCLUSION

The conclusion that can be drawn from all stages of this study is the achievement of increased understanding of concepts and digital literacy in the experimental class based on the implementation of the HoSEL model. This study proves that the HoSEL model is effective in improving the understanding of chemical concepts and digital literacy of MA DDI Jayapura students. The achievement of conceptual understanding without the HoSEL model and using HoSEL is relatively stable, only not very significant in the experimental class. However, before the HoSEL intervention, students' digital literacy was very low (N-Gain 0.12), but after the implementation of HoSEL, the increase in digital literacy became high (N-Gain 0.79). In addition, students showed high enthusiasm for technology-based learning provided in the HoSEL model. Thus, the HoSEL model is one of the effective chemistry learning models, so this model is very good to continue to be maintained. The implications of this study are the need for teacher training in integrating digital technology into learning, as well as the development of supporting infrastructure such as internet access and digital devices. The HoSEL model can also be adapted to other subjects and regions with similar challenges.

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