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The Use of Problem Based Interactive Video Quizzes to Improve Students' Chemical Literacy on the Topic of Water Pollution

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Abstract. This study is grounded in the importance of students having chemistry literacy related to the issue of water pollution through problem-based learning (PBL) integrated with interactive video quizzes. The purpose of the research was to describe the use of problem-based interactive video quizzes and to analyze the improvement of students' chemistry literacy on the topic of water pollution. The research design employed a one-group pretest-posttest with 31 tenth-grade students from a secondary school in West Java as subjects. The instrument used was a chemistry literacy test measuring the aspects of content, context, process, and attitude toward water pollution. The results showed the highest N-Gain increase in the attitude indicator (0.70), followed by context (0.65), content (0.62), and process (0.58). Based on these findings, it can be concluded that the use of PBL integrated with interactive video quizzes can significantly improve students' chemistry literacy, with the highest improvement observed in the attitude aspect and the lowest in the process aspect.
Keywords: Problem-based learning, interactive video quiz, chemistry literacy, water pollution

Introduction

Chemistry does not merely focus on the mastery of abstract concepts or multidimensional understanding through the three levels of representation macroscopic (observable phenomena), submicroscopic (particle interactions), and symbolic (chemical formulas. Beyond that, the essence of chemistry lies in the ability to connect these three levels with real life contexts relevant to students' lives (Sunarya et al., 2023). The study conducted by Sunarya et al. (2024) it demonstrates that this skill can significantly improve student learning outcomes, especially when instruction is linked to real-world issues such as the water pollution crisis a relevant and urgent global concern. This is in line with the findings of Meiwinda et al. (2023) which shows that students who are engaged in analyzing water pollution through a chemistry-based approach not only develop a better understanding of chemical concepts but also cultivate a greater awareness of environmental issues (Ramachandran et al., 2021). It affirms that integrating environmental contexts into chemistry learning not only makes the material more applicable, but also deepens students' conceptual understanding.

Water pollution, as one of the global environmental issues, is highly relevant to be explored through a chemistry based approach (Sjöström et al., 2024). Chemistry learning that integrates environmental issues can help students gain a deeper understanding of the chemical processes involved (Williams, 2022). This phenomenon is inseparable from chemical processes such as the degradation of organic matter, pH changes, heavy metal precipitation reactions, and interactions of toxic compounds with aquatic ecosystems (Walker & Li, 2016). This indicates that understanding chemical concepts such as redox reactions, solubility, and molecular structure is crucial for explaining water pollution phenomena. Research findings show that learning through real-world controversial issues can enhance students' ability to make evidence-based decisions (Miller & Czegan, 2016).

The urgency of addressing water pollution issues is increasingly evident from empirical field data. A report from the Ministry of Environment and Forestry (KLHK) states that more than 50% of rivers in Indonesia, including the Ciliwung River, are heavily polluted (Kementerian Lingkungan Hidup, 2010). Limbah domestik tercatat sebagai penyumbang utama pencemaran mencapai 47,62%, followed by industrial waste at 33.33% and urban waste at 19.04%. Several studies indicate that the Ciliwung River experiences varying levels of pollution, ranging from mild to severe, based on the pollution index. Moreover, high concentrations of microplastics have been found, correlating with population density along the river flow, particularly originating from household plastic waste (Yang et al., 2025). These data underscore the importance of a comprehensive understanding of water pollution and its solutions, particularly through chemistry education

However, chemistry learning in schools is still dominated by memorization of information and exam-oriented approaches (Mabrouk, 2024). As a result, students struggle to critically relate chemical concepts to environmental issues (Nagarajan & Overton, 2019). In the topic of water pollution, students tend to merely memorize definitions and types of pollutants without understanding the chemical processes involved and their impacts on ecosystems and human health. The disconnect between theory and real-world contexts results in low scientific awareness and concern among students regarding environmental issues, including the declining availability of clean water due to pollution. Therefore, chemistry learning needs to be directed towards strengthening students' understanding that water pollution is a highly relevant issue closely linked to chemical concepts and requires scientific analysis skills for its resolution, as well as the development of students' critical thinking skills (CTS) (Costantino & Barlocco, 2019). Research findings reveal that students are more active and engaged in discussions on relevant scientific and social topics (Ramachandran et al., 2021). Therefore, strengthening chemical literacy is crucial as it equips students with the ability to interpret scientific data, analyze natural phenomena, and apply chemical knowledge in everyday life.

In line with the above perspective, various research findings have shown that problem based learning (PBL) can promote students' CTS. Hui et al. (2025), It helps students better understand concepts through data analysis, enabling them to make scientific decisions related to environmental issues, approach is based on constructivism, using real world problems as a starting point to encourage students to collaboratively build knowledge through inquiry and problem-solving processes, with the teacher acting as a facilitator (Pan et al., 2021). Nevertheless, the implementation of PBL for complex topics such as water pollution still faces several challenges. These include limited instructional time, difficulties in presenting complex environmental issues in the classroom, and the diversity of students' cognitive ability levels (Warfa et al., 2022). To overcome these challenges, the integration of educational technology based on interactive videos offers a very promising solution. Interactive video based quizzes enable students to learn independently while simultaneously assessing their understanding through the videos (Aziimah & Ammar, 2024).

Edpuzzle (https://edpuzzle.com/) is an interactive video-based learning platform that allows teachers to modify educational videos by adding questions, comments, and narrations for students. The platform also enables teachers to monitor student engagement and provide questions and feedback within the instructional videos at specific intervals (Silverajah & Govindaraj, 2018). Edpuzzle’s alignment with the syntax of PBL lies in its ability to present problems in an engaging visual format, promote student learning autonomy, and develop high order thinking skills (HOTS) (Mischel et al., 2022). Another advantage of Edpuzzle is the inclusion of questions interspersed throughout the video, which actively engages students in constructing understanding during the learning process (Van et al., 2018). In addition, Edpuzzle can provide immediate formative feedback and allows teachers to monitor student progress and adjust instruction accordingly (Urban et al., 2017).

The use of interactive videos in chemistry learning can enhance students’ cognitive engagement and conceptual understanding of complex chemical phenomena (Ahmed & Faris, 2025). Several studies have shown that the use of interactive videos in chemistry learning can improve students’ cognitive engagement and conceptual understanding of complex chemical phenomena (Wang & Tan, 2023). Edpuzzle has also been effective in enhancing students’ motivation, conceptual understanding, and participation across various subjects, such as science and biology (Nurlaila, 2024). This highlights the great potential of Edpuzzle as an interactive video-based medium to be integrated with PBL in chemistry learning, particularly on the topic of water pollution.

The novelty of this study lies in the synergistic integration of Edpuzzle with PBL on the topic of water pollution, while emphasizing the comprehensive development of chemical literacy including content, context, scientific process, and students' scientific attitudes which have often been limited to cognitive or conceptual understanding alone. This article discusses how the Edpuzzle platform was utilized in teaching the topic of water pollution and examines the profile of students’ chemical literacy after the implementation of the learning.

Methods

This study employed a one-group pretest-posttest design. This design involved a single group of students who were given a pretest, followed by a treatment in the form of learning through interactive video quizzes using the Edpuzzle platform integrated with PBL stages, and finally a posttest to measure changes in chemical literacy after the intervention. The research subjects consisted of 31 tenth-grade students from a vocational high school (SMK) in Bogor City. The selection was based on purposive sampling, a technique in which the sample is selected based on specific considerations (Notoatmodjo, 2010).

The instrument used to measure chemical literacy was a multiple-choice test consisting of 20 items covering four indicators: content, context, process, and attitude in chemistry. The chemical literacy test instrument was validated prior to use. Content validation was conducted by two experts in chemical education and one chemistry teacher. Subsequently, the instrument was tested using the Anates software, and the results indicated that the discrimination index ranged from 66.67 to 100%, with the majority of items falling under the "moderate" difficulty level. The item validity values ranged from 0.456 to 0.913, with 15 items categorized as "highly significant" and 5 items as "significant." The distractors in the test functioned effectively, as evidenced by the variation in the qualifications of each answer option. Effective distractors indicate the instrument's ability to distinguish between students who have mastered the material and those who have not (Sudijono, 2018). Overall, the developed chemical literacy test instrument met the criteria of a good instrument in terms of discrimination power, difficulty level, and validity. Therefore, it was deemed appropriate for measuring students' chemical literacy in learning.

The chemical literacy data were processed through several stages. First, a normality test was conducted to determine the distribution of the pretest and posttest data. Based on the normality test results, the data were further analyzed using a hypothesis testing procedure to examine the significance of the improvement in students' chemical literacy. In addition, to evaluate the effectiveness of the learning approach, an N-gain calculation was performed to measure the proportional increase in students' abilities from pretest to posttest, and to assess learning improvement and the success of the instructional method (Hake, 1998).

During data analysis, students were grouped into high, medium, and low achievement categories. This grouping was conducted to analyze differences in the improvement of chemical literacy among students with varying levels of academic performance. Pretest and posttest data were calculated for each chemical literacy indicator (content, context, process, and attitude) within each student achievement group. The N-gain analysis was conducted specifically for each achievement group on each chemical literacy indicator, rather than based on the total sample. This approach provided a detailed description of the improvement in chemical literacy for each indicator across different achievement levels, enabling a more in-depth analysis of the effectiveness of Edpuzzle-integrated PBL for students with varying levels of ability.

Results and Discussion

The research findings are presented in accordance with the stated objective, namely to analyze PBL integrated with interactive video-based quizzes to enhance students' chemical literacy on the topic of water pollution

Problem Based Interactive Video Quizzes

The problem-based interactive video quiz is a learning model that utilizes interactive videos allowing students to engage directly with video content through various elements, one of which is quiz questions. This model is implemented using the stages of PBL (Fernández et al., 2023). The aim of implementing a problem-based interactive video quiz is to train students in critical thinking, develop a deep understanding of concepts, and apply knowledge to solve problems (Pulukuri & Abrams, 2020). This study was conducted in the context of a chemistry subject over two sessions. The first session included the initial stages of problem orientation through problem investigation. The second session continued with the stages of developing and presenting solutions, followed by analyzing and evaluating the results of the investigation. The integration of Edpuzzle into the PBL learning model is illustrated in Figure 1. This framework shows how each stage of PBL is aligned with specific indicators of chemical literacy to support students' understanding of water pollution.

The problem orientation stage began with the presentation of an interactive learning video depicting the initial condition of a river prior to pollution. The river was portrayed as a healthy ecosystem, characterized by clear and clean water, high biodiversity, and its social and economic functions for surrounding communities (Ohlenburg et al., 2024). The narration then transitioned to explaining the ecological changes caused by pollution from domestic wastewater (e.g., water containing detergents), agricultural runoff (containing nitrate and phosphate compounds from fertilizers, as well as pesticides), and industrial waste (potentially containing heavy metals such as Pb, Cd, and Hg, along with hazardous organic chemicals), as illustrated in Figure 2. A scene from the first video on river water pollution displayed the polluted river conditions through visuals such as murky water due to an increase in total suspended solids (TSS), floating detergent foam indicating the presence of surfactants, and piles of trash along the riverbanks. The video also featured actual news footage on river pollution, marked by the appearance of foam as an indicator of high concentrations of surface-active agents (surfactants) in the water. The purpose of the video was to raise students' initial awareness of the reality of water pollution through a real-world case study of the Ciliwung River. By visualizing the transformation of the river from clean to polluted, students were expected to analyze the contributing factors of pollution and understand its impact on water quality and the river ecosystem. In this way, the video aimed to foster students' CTS in identifying environmental issues through contextual observation.

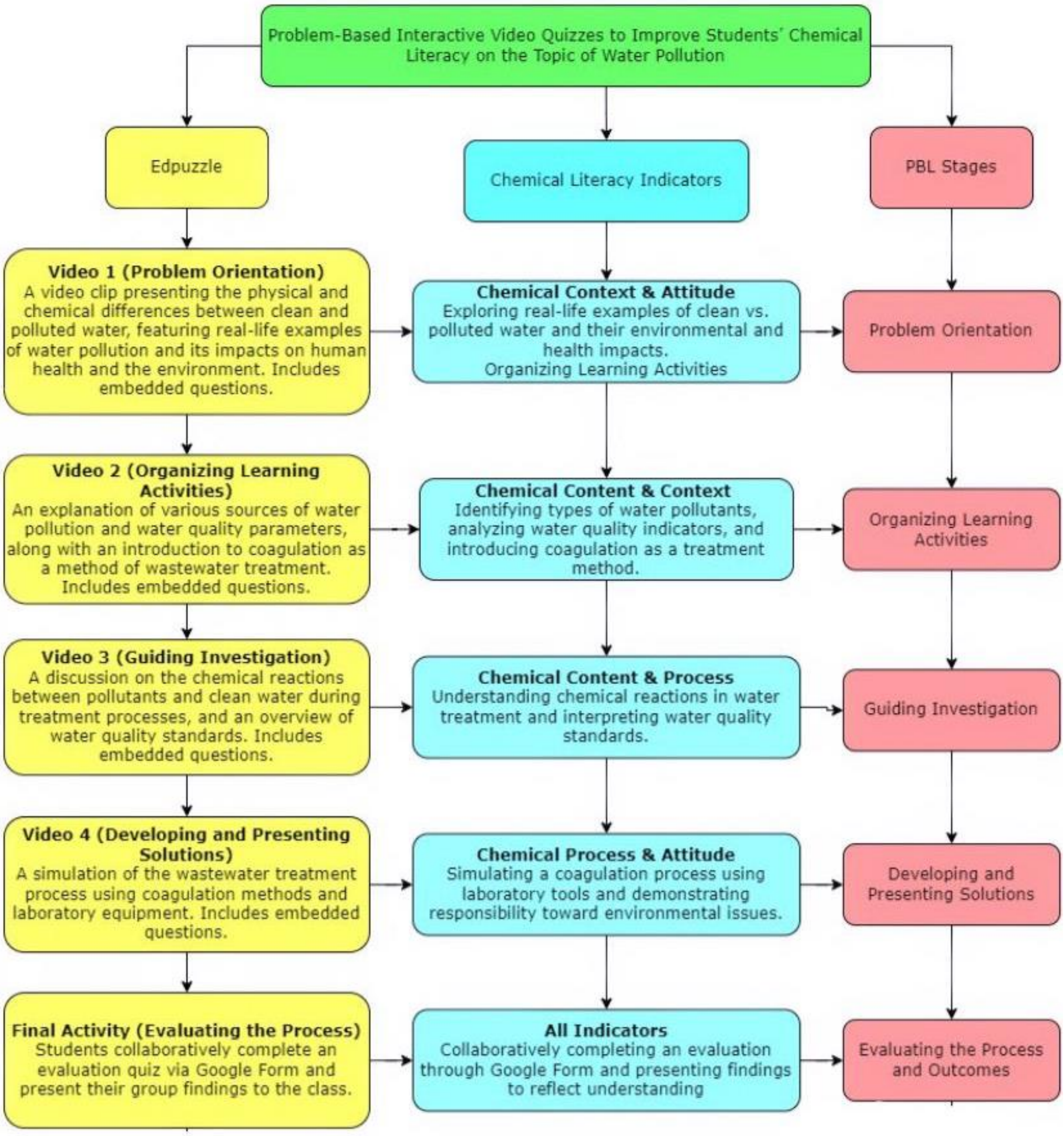

Figure 1. Framework of PBL integrated video interactive using edpuzzle to improve students' chemical literacy on the topic of water pollution

Six multiple-choice questions regarding the characteristics of polluted rivers, ecological impacts, and river functions were embedded throughout the video to support students' conceptual understanding during the learning process (Van et al., 2018). These questions were designed to enhance students' analytical thinking skill (ATS) and evaluative skills while connecting chemical concepts with real-life environmental contexts that are relevant to their daily lives. Through this activity, students were able to identify and analyze the problems in order to determine the knowledge gaps they needed to bridge in solving the issues (Christiansen et al., 2017).

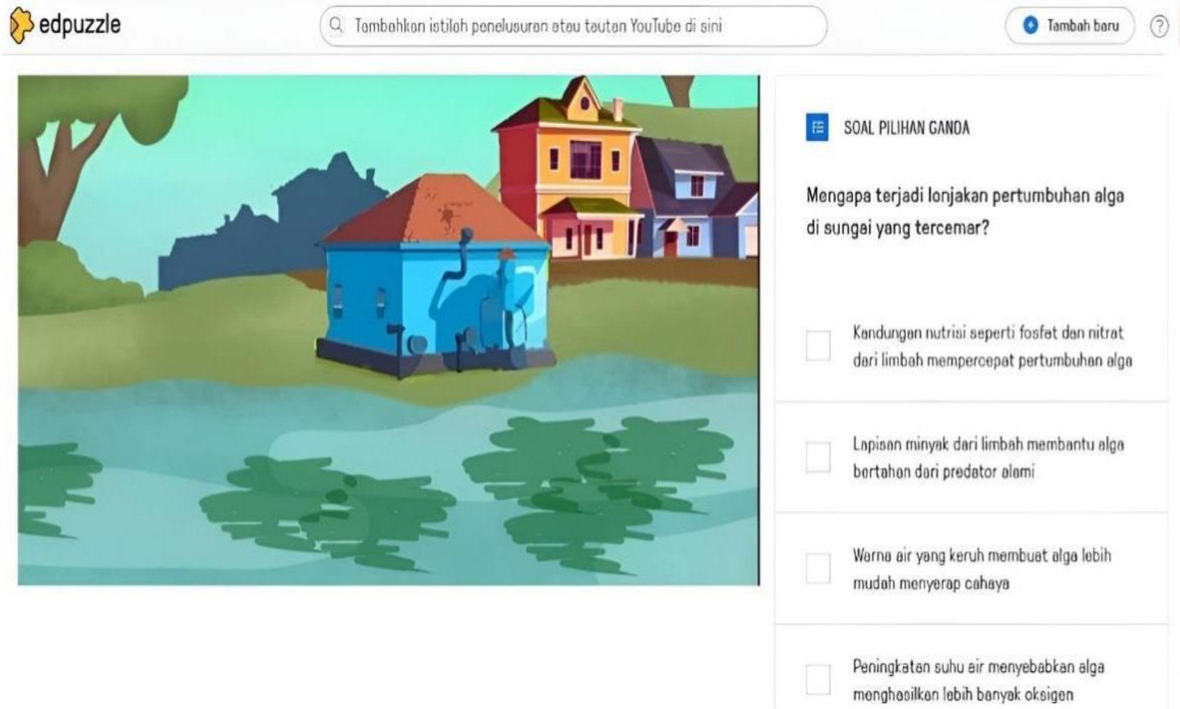

Figure 2. Snapshot of stage 1 video on water pollution in the Ciliwung River

The second stage is student organization, which aims to encourage students to seek answers to the presented problems and to develop skills in selecting relevant information (Hui et al., 2025). The learning process was facilitated through Edpuzzle, which covered fundamental concepts of water pollution. It began with the definition of water pollution, as shown in Figure 3 a video excerpt from stage 2 on water pollution followed by the characteristics of clean water and national standards for water quality parameters.

Six questions were embedded in the video to guide students in linking changes in the physical, chemical, and biological properties of water to its functionality. The purpose of this video was to systematically introduce the scientific concept of water pollution (Morgan et al., 2025), including the physical, chemical, and biological parameters used to assess water quality. The video strengthened students' ATS in evaluating water feasibility based on standard water quality data and helped them connect parameter changes such as dissolved oxygen (DO), pH, total dissolved solids (TDS), and turbidity with the actual condition of polluted water. Students were also trained to evaluate the suitability of water for various uses based on scientific data.

Figure 3. Snapshot of stage 2 video on water pollution

The next stage, guiding the investigation, aims to promote student autonomy, chemical literacy skills, and deeper conceptual understanding (Dražić & Devetak, 2025). The learning process was facilitated through Edpuzzle, which presented a video on various sources of water pollution, types of waste, and the environmental and human health impacts of pollution, including phenomena such as eutrophication, ecosystem degradation, and disruption of the food chain. As illustrated in Figure 4 an excerpt from the stage 3 video on types of waste and the impacts of water pollution the video also emphasized the importance of pollution prevention through waste management and the use of environmentally friendly products (Farida et al., 2017). Waste management learning was delivered contextually by linking the chemical content of waste to its impact on ecosystems and human health. For example, the toxic effects of heavy metals such as Pb, Cd, and Hg, which can cause organ damage and developmental disorders in living organisms, were highlighted.

Six questions embedded in the video explored students' understanding of different types of waste based on their sources and chemical properties. Additionally, students were guided to classify waste categories, recognize potential sources of water pollution, and explain the health impacts of pathogenic microorganisms and heavy metals. The video aimed to deepen students' understanding of the types and sources of pollutants, their consequences for ecosystems and human health, and to foster environmental awareness by demonstrating the importance of active efforts in combating pollution (Jansson et al., 2015).

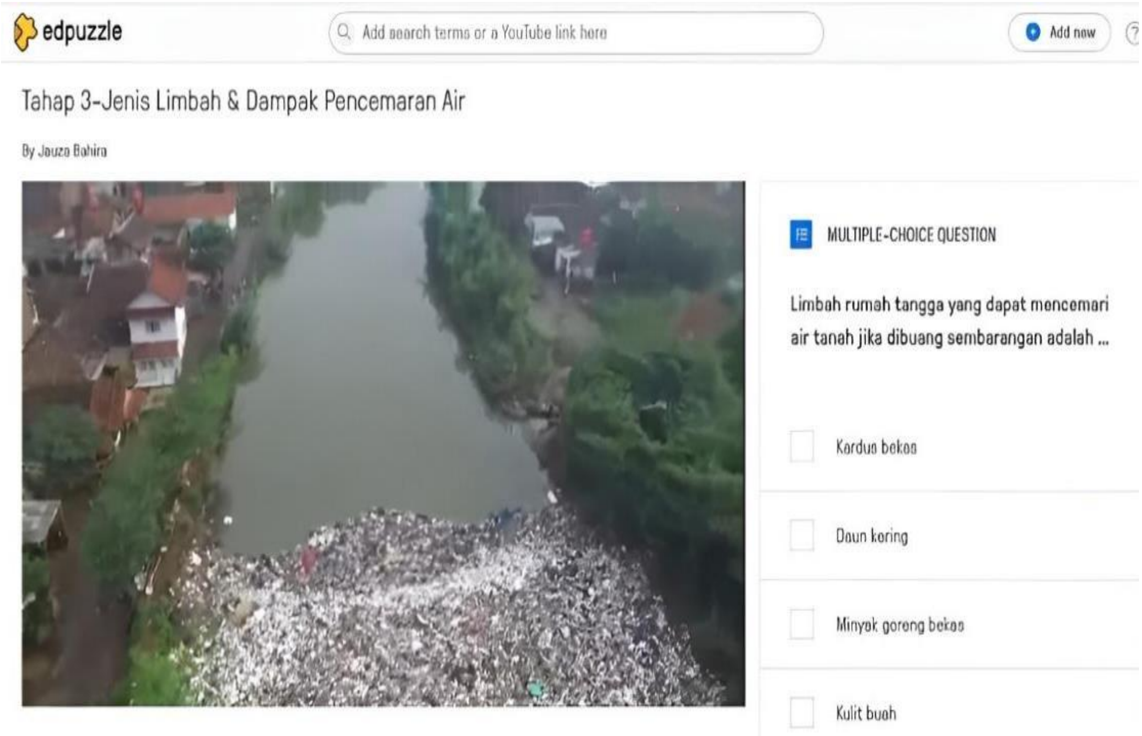

Figure 4. Snapshot of stage 3 video on types of waste and the impact of water pollution

The fourth stage, which involves developing and presenting the results of students' work, aims to transform information into knowledge and collaboratively formulate solutions (Wellhöfer & Lühken, 2021). The learning process was facilitated through Edpuzzle, which presented a video on the coagulation flocculation experiment, playing a crucial role in supporting meaningful learning. The video not only visualized the coagulation process but also included narration explaining fundamental scientific principles, such as the working mechanism of alum (aluminum sulfate) as a coagulant in clarifying domestic wastewater. As shown in Figure 5, a clip from the video in stage four illustrates how to address water pollution. The video details the mechanism of alum as a coagulant, beginning with the hydrolysis of aluminum sulfate to form aluminum hydroxide, which then acts as a flocculant. This compound works by adsorbing and binding suspended particles in domestic wastewater, enabling the formation of larger flocs that eventually settle as solid sludge. Coagulation flocculation is a physico chemical process aimed at removing suspended particles, colloids, and organic substances from water.

Three questions were embedded in this video to explore students' procedural and scientific understanding of the coagulation flocculation method. Students were asked to identify the tools and materials used in the jar test, explain the experimental steps in sequence, and answer a question regarding the working principle of coagulation. The focus of the evaluation in this video was on how the process contributes to reducing water turbidity and the importance of floc sedimentation in wastewater treatment. The main objective of this video was to guide students in understanding concrete solutions to water pollution through the coagulation flocculation practice using the jar test method. The video presents the scientific procedure in a structured manner, including the tools, materials, and experimental steps, thereby encouraging students to develop procedural and ATS. Additionally, students were prompted to evaluate the effectiveness of coagulants such as alum in reducing turbidity and to relate this to improvements in water quality based on measurable chemical parameters.

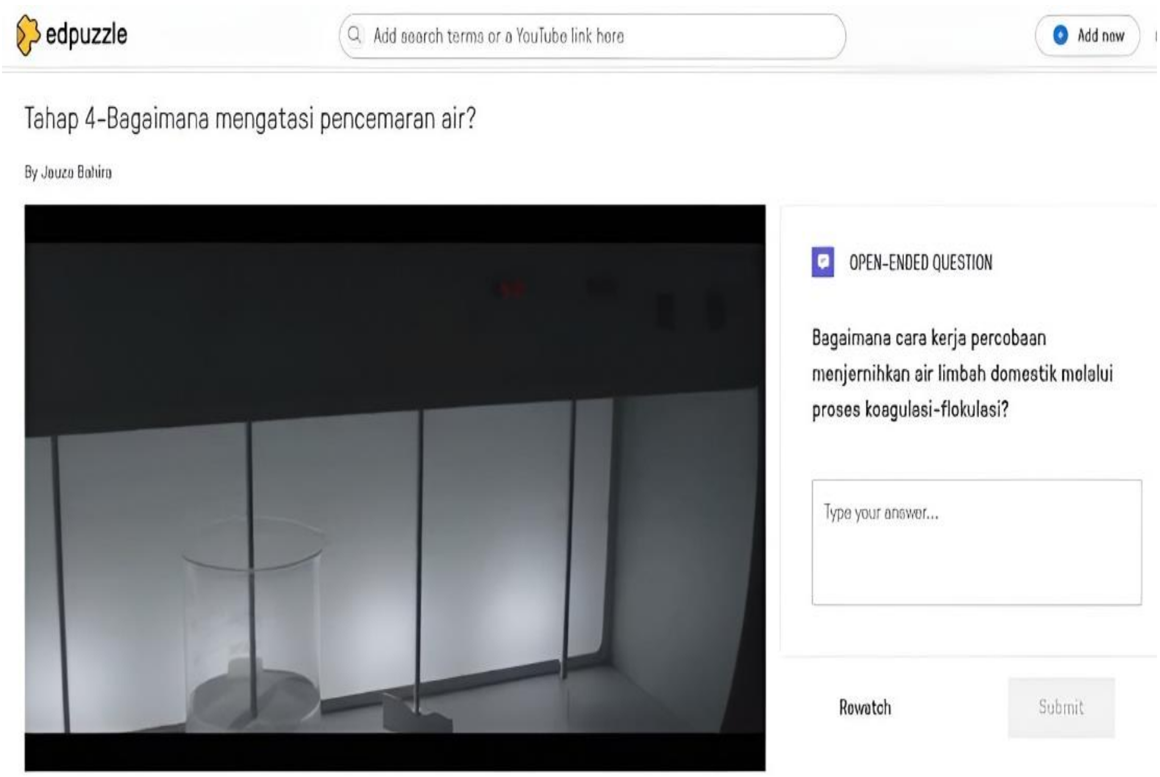

Figure 5. Snapshot of stage 4 video on strategies for addressing water pollution

In the fifth stage, which involves analyzing and evaluating the investigation results, students participated in a series of learning activities through Edpuzzle. Subsequently, students answered evaluation questions via google forms, consisting of three essay questions completed in groups of 5–6 students, focusing on water pollution in the Beji River. The questions at this stage were based on a case study using real data from the Beji River. Students were asked to analyze physical and chemical parameters from four monitoring stations. The presented questions guided students to evaluate the main causes of pollution, express a scientific attitude towards the pollution, and propose practical, data-driven solutions.

Chemical Literacy Skills

The study was conducted in three stages. The first stage involved administering a pretest to assess students' prior knowledge related to the topic of water pollution. Next, the second stage consisted of an intervention using Edpuzzle as an interactive video learning media. After the learning process was completed, the third stage was carried out by giving a posttest to measure the improvement in students' understanding following the intervention.

Data analysis of normality tests on pretest and posttest results across three achievement groups was conducted using the Shapiro-Wilk test. The selection of the Shapiro-Wilk test was based on the consideration that the sample size in each achievement group was less than 30, making this test more appropriate for assessing normality in small samples (Notoatmodjo, 2010). The normality test results indicated variation in data distribution among the different groups.

In the high achievement group, the significance value for the pretest data was 0.217 > 0.05, indicating that the data were normally distributed. However, the significance value for the posttest data was 0.032 < 0.05, showing that the data were not normally distributed. A similar condition was found in the moderate-achievement group, where the significance value for the pretest data was 0.189 > 0.05, while for the posttest data it was 0.046 < 0.05. In the low-achievement group, the significance value for the pretest was 0.224 > 0.05, and for the posttest, it was 0.042 < 0.05. The normality test results indicating non-normal data distribution across the high, moderate, and low achievement groups suggest variability in students' chemical literacy skills that do not follow a normal distribution curve.

Subsequently, the Wilcoxon test was conducted, and the results showed a significant difference between the pretest and posttest scores in all achievement groups. In the high achievement group, the Z value was -2.803 with a p-value of 0.005 (< 0.05), indicating a significant increase from a pretest mean of 76.5 to 91.8, or a 20.0% improvement. For the moderate-achievement group, the Z value was -3.062 with a p-value of 0.002 (< 0.05), showing an increase from an average of 64.3 to 80.8, or 25.7%. Meanwhile, in the low-achievement group, the Z value was -2.521 with a p-value of 0.012 (< 0.05), with the mean rising from 47.6 to 66.8, representing a 40.3% improvement. An interesting pattern emerged where the low-achievement group showed the highest percentage increase, indicating that the learning integrated with Edpuzzle had the most significant impact on students with lower initial abilities, although all groups demonstrated statistically significant improvements. The significance across all achievement levels suggests that Edpuzzle, as an adaptive learning medium, has the flexibility to accommodate the learning needs of students with varying abilities. This finding is consistent with previous research showing that embedding interactive questions and requiring full video completion significantly enhance student accountability and engagement in chemistry learning contexts (Pulukuri & Abrams, 2021).

Next, data analysis was conducted using the N-Gain test. Based on the chemical literacy test results on the topic of water pollution presented in Table 1, differences in N-Gain values can be observed for each chemical literacy indicator across the high, medium, and low achievement groups. This N-Gain analysis provides an overview of the effectiveness of the learning process in improving students' chemical literacy. The following discussion elaborates on each chemical literacy indicator based on these data.

Table 1. Recapitulation of N-gain scores for chemical literacy indicators

Chemical Literacy Indicators	N-Gain			Average N-Gain
	High	Medium	Low	
Chemical Content	0.78	0.65	0.42	0.62
Chemical Context	0.82	0.68	0.45	0.65
Chemical Process	0.75	0.61	0.38	0.58
Chemical Attitude	0.86	0.72	0.51	0.70
Average N-Gain	0.80	0.67	0.44	0.64

In the chemical content indicator, the N-Gain values were 0.78 for the high achieving group, 0.65 for the moderate-achieving group, and 0.42 for the low-achieving group, with an average N-Gain of 0.62. These results indicate a significant improvement in students' ability to understand theoretical chemistry concepts and materials, particularly in the high-achieving group. The high achieving group was able to absorb and integrate chemical content effectively, likely due to a better prior knowledge base. This finding aligns with research suggesting that content understanding is a fundamental aspect of chemical literacy, and students with higher academic abilities tend to show greater improvement in content comprehension (Shwartz et al., 2021). In addition, studies have shown that N-Gain analysis although widely used to evaluate instructional effectiveness is sensitive to students' prior knowledge, with learners who have stronger initial understanding tending to achieve higher gains (Brewe et al., 2016).

In the chemical context indicator, the high achieving group obtained the highest N-Gain value (0.82), followed by the moderate-achieving group (0.68) and the low-achieving group (0.45), with an average of 0.65. These results indicate that students with higher achievement levels are better able to connect chemistry concepts related to water pollution with real-world phenomena, such as associating industrial activities with river pollution or detergent use with groundwater quality. This improvement aligns with research emphasizing that contextual learning enhances the relevance and understanding of chemistry in daily life (Nagarajan & Overton, 2019). The low-achieving group still faces difficulties in applying their understanding of water pollution to real-life contexts (Avraam et al., 2025).

Next, the chemical process indicator shows N-Gain values of 0.75 for the high-achieving group, 0.61 for the moderate-achieving group, and 0.38 for the low-achieving group, with an average of 0.58. Previous research has shown that Edpuzzle-prepared videos can enhance students' retention of scientific content and readiness for laboratory experiments, underscoring the platform's potential to support the development of ATS quality, interpret test data, and explain pollution phenomena based on scientific evidence (Shelby & Fralish, 2021). The considerable performance gap between high- and low-achieving groups may be linked to the cognitive complexity involved in analytical tasks related to water pollution. Scientific process skills require repeated practice, as students need to engage in iterative cycles of planning, conducting investigations, analyzing data, and revising procedures to build proficiency in laboratory practices (Stephenson et al., 2020). Thus, students with lower achievement levels need more intensive guidance in conducting water quality testing and analysis.

For the chemistry attitude indicator, the highest N-Gain values among all indicators were recorded: 0.86 for the high-achieving group, 0.72 for the moderate-achieving group, and 0.51 for the low-achieving group, with an average of 0.70. This substantial improvement indicates that the instructional intervention successfully fostered students' awareness and concern regarding water pollution issues. Students became more sensitive to the impacts of water pollution and were motivated to participate in maintaining water quality. These findings align with previous research showing that meaningful learning experiences, such as water pollution cases relevant to students' lives, are effective in enhancing positive attitudes toward science (Avraam et al., 2025b). Supporting evidence also suggests that practical learning experiences such as those involving water purification materials can significantly foster student engagement, environmental concern, and contextual understanding of chemistry (Luzzi et al., 2021).

The average N-Gain scores for the high, moderate, and low achievement groups were 0.80, 0.67, and 0.44, respectively, indicating that all groups experienced improvements in chemical literacy within the context of water pollution following the instructional intervention. The chemistry attitude indicator showed the highest increase (0.70), reflecting the success of the learning process in raising awareness about the importance of maintaining water quality. Meanwhile, the chemistry process indicator had the lowest average gain (0.58), highlighting the need to strengthen practical experiments and field investigations related to water pollution.

These results align with previous studies emphasizing the importance of contextual chemistry learning to enhance chemical literacy. Furthermore, the development of comprehensive chemical literacy requires a combination of content mastery, application in relevant contexts, process skills, and the cultivation of positive attitudes toward chemistry and the environment (Dražić & Devetak, 2025). The integration of problem based interactive video quizzes has been proven to facilitate the multidimensional development of chemical literacy, consistent with research findings on the effectiveness of interactive video based learning in environmental chemistry education (Ahmed & Faris, 2025). To reduce the achievement gap among student groups, a learning approach involving water pollution phenomena close to students' daily lives such as local river pollution case studies or drinking water quality analysis is needed. Differentiated learning strategies that utilize adaptive technology present a promising approach to accommodate the diverse learning needs of students with varying ability levels (Avraam et al., 2025). The effectiveness of this approach is further supported by evidence that digital, complexity-differentiated modules enhance students' conceptual understanding, motivation, and engagement, especially for those with lower prior achievement (Horst et al., 2024).

The observed N-Gain achievements are closely linked to several learning conditions that influence the internalization process of chemical concepts by students. The Edpuzzle media used in this study provided students with the opportunity to review the learning material multiple times. The applied learning dynamics also played a crucial role in the outcomes obtained. Although students were arranged in groups and allowed to discuss, the responses on Edpuzzle were still completed individually. This arrangement created a space for students to collaborate in constructing understanding while maintaining personal accountability in demonstrating mastery of the material. This learning model is consistent with previous research showing that embedding questions within flipped classroom videos enhances conceptual understanding while maintaining student engagement (Petillion & McNeil, 2020).

The limited instructional time of 2×45 minutes across two sessions also contributed to the results obtained. Some aspects of understanding particularly those requiring HOTS might not have been fully developed. This finding is consistent with (Avraam et al., 2025), who reported that time constraints in classroom instruction can significantly affect the effectiveness of context based and technology integrated strategies, often requiring the compression of complex content into limited periods.

Conclusion

The problem-based interactive video quiz successfully enhanced students' chemical literacy skills on the topic of water pollution. The highest N-Gain was observed in the chemical attitude indicator (0.70), followed by context (0.65), content (0.62), and process (0.58). Overall, this approach was most effective in improving attitudes and understanding but requires refinement in developing students' scientific skills.

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