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Innovation of the LIRACLE Model: Case of Gajah Wong River Pollution by Pb Metal

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Abstract

Gajah Wong River is one of the rivers in Yogyakarta. Gajah Wong River is an aquatic ecosystem whose existence is greatly influenced by activities or activities around it or in the river basin. Several human activities cause pollution in this river. One of the pollutants found is Pb metal. Students, as a quality young generation, must be able to find alternative solutions to this problem. Literacy and Research-Oriented Cooperative Problem-Based Learning (LIRACLE) is a new learning model developed for learning in higher education. In its development, LIRACLE is used to develop chemical literacy skills, get used to scientific thinking, and develop the science process skills of prospective chemistry teachers. The purpose of this study is to describe the application of the LIRACLE model in the case of pollution of the Gajah Wong River by Pb metal. The description includes observations of the implementation of each syntax of LIRACLE. The number of water samples used in this study was taken from one point on the Gajah Wong River. The chemical concept studied is adsorption, the theory of which has been studied in the "Molecular Dynamics" course. The results of this study are descriptions of activities in each LIRACLE syntax in the case of Gajah Wong River pollution by Pb metal. This study is preliminary in the development of the LIRACLE model for the future.

Keywords: *Pb metal, LIRACLE learning model, Gajah wong river pollution*

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INTRODUCTION

The development of Science and Technology has caused the world to enter an era of disruption. The era of disruption has become a reality that must be faced by the world community, including Indonesia (Pratama & Rohaeti, 2023). The impact of this era has caused the young generation of Indonesia to be qualified and able to compete at the global level to meet the demands of success in work and the future of the young generation (Pratama et al., 2023). However, forming a quality young generation still faces many obstacles, such as low enthusiasm for collaboration, lack of literacy skills, and low problem-solving skills (Edwards et al., 2023; Perry et al., 2023).

A country's young generation's quality can be seen from its undergraduate students. This is based on the age range of undergraduate students who are generally between the ages of 18–23 years. Therefore, the development of student abilities must be pursued by providing quality and the best possible education (Pratama et al., 2023). However, research by the Program for International Assessment of Adult Competencies (PIAAC) in 2016 also showed that students are still very weak in terms of literacy and problem solving (Perry et al., 2020). The results of PIAAC showed that 70% of respondents from Indonesia had literacy skills at level 1 and below, indicating that the young generation of Indonesia is only able to read short texts with topics that are familiar to them and are only able to capture one message or information from the text (Keslair and Paccagnella, 2020).

Problem-Based Learning (PBL) offers an alternative solution to develop literacy and problem-solving skills by integrating science into a real-life case (Akcay & Benek, 2024; Cavadas et al., 2022). This is because the main point of PBL is to encourage students to be active and improve the development of student abilities (Barret, 2017; Brilingaite et al., 2018). Therefore, PBL is included in the student-centered learning model, and lecturers have a crucial role as facilitators for the success of learning. However, in addition to having many advantages, PBL has several disadvantages. The role of students in the learning process is difficult to change because they are used to being oriented towards subject matter and remembering facts (Grant, 2002).

PBL also requires a lot of time to solve complex problems (Grant, 2002). In addition, assessment of learning outcomes will be difficult if done in a traditional way, such as using written exams (Shankar, 2010). To minimize the shortcomings of PBL, lecturers must emphasize their role as facilitators (not just providing material directly to students). In addition, clear rules regarding learning and assessment must be agreed upon together (Shankar, 2010). Therefore, innovation to adapt PBL into a new learning model can be done to overcome the shortcomings of PBL.

Development of the LIRACLE Model

Previous studies have revealed the importance of chemical literacy skills, scientific thinking habits, and science process skills that must be possessed by undergraduate students in the science education group, especially undergraduate students in Chemistry Education (Pratama et al., 2024). However, in reality, there are still many cases of low chemical literacy skills among students (Muntholib et al., 2020). Students have not been able to connect the knowledge gained in class and real life (Stasevic et al., 2023). In addition, in the psychomotor aspect, there were findings of a decrease in science process skills along with the increasing year of study of students (Çalık et al. 2015). The same results were stated by Cigdemoglu et al (2017), who said that there was a decrease in student attitudes after receiving instructions, although not significant.

Innovation in chemistry learning must be carried out to prepare students to become professional teachers in the future (Easa & Blonder, 2024). One form of innovation is to develop a new learning model that is specifically aimed at learning in higher education. However, there have not been many developments of learning models that focus on adult learning. The LIRACLE (Literacy and Research-Oriented Cooperative Problem-Based Learning) learning model was developed to be an innovation. LIRACLE was developed specifically to develop chemical literacy skills, get used to scientific thinking, train science process skills, train cooperation, and get students used to research. Currently, LIRACLE is still in the development stage and has six syntaxes that must be run sequentially. The six syntaxes are combined with the concept of adsorption chemistry to create a learning environment that is oriented towards literacy and research to solve problems in everyday life. The advantages of the LIRACLE model are: it can be a learning model that can teach chemical literacy, teach scientific thinking, and hone students' science process skills; it can increase student activity; it can help students work together to solve a problem; it can help students develop new knowledge and be responsible for the learning they do; it can help students transfer the knowledge they have to understand problems in real life; it can introduce students to the world of literacy and the world of research; structured assignment systematics. In addition to its advantages, LIRACLE also has weaknesses: when students do not have interest or do not have confidence that the problem being studied is difficult to solve, they will be reluctant to try; If the materials used by students in making experiments are difficult to find, this will be a challenge to think of substitute materials.

Gajah Wong River Pollution Case

Gajah Wong River is one of the rivers that divide the city of Yogyakarta. Gajah Wong River is an aquatic ecosystem whose existence is greatly influenced by activities or activities around it or in the river basin. The upstream part is on the slopes of Merapi, Sleman Regency, while the downstream part is in Bantul Regency. The high activity that occurs causes this river to be susceptible to pollution, especially Pb metal, both in biota and waters (Melati et al., 2022).

One of the problems related to water is the difficulty of obtaining clean water (Pratama, 2022). Well water is one of the main sources of clean water used by people for their daily needs, especially in rural areas (Purba, 2019). However, problems with the quality of well water often arise, especially when well water is contaminated by substances carried by rainwater, such as lead (Pb). High levels of Pb in well water can cause a metallic taste, stains on equipment, and negative effects on health if consumed in the long term (Susilo, 2021).

Zeolite as Adsorbent

Zeolite is a group of minerals produced from the hydrothermal process. The main forming units that build the structure of zeolite minerals are SiO_2 and Al_2O_3, which form tetrahedra where each oxygen atom is at its four corners. The main frame structure of zeolite is occupied by silicon or aluminum atoms with four oxygen atoms at each corner. This structure is the active side of zeolite, which causes zeolite to have the ability to act as an adsorbent (Kristiyani et al., 2012)

Figure 1. Gajah Wong River

RESEARCH METHOD

This study is a qualitative descriptive study to see each learning activity using the LIRACLE learning model. The study took place in the Chemistry Education Study Program for one semester. The instrument used in this study was a learning observation sheet (observation logbook), which was used to describe all learning activities from each LIRACLE syntax. This study is a preliminary step to the development of the LIRACLE learning model, which will be tested for its effectiveness in the future.

RESULT AND DISCUSSION

The research that has been conducted describes each syntax of the LIRACLE learning model. The first syntax of the LIRACLE learning model begins with an apperception activity, which is then continued with the activity of dividing students into small groups of 3 to 5 students. The next activity is that students are given a chemical literacy discourse with the topic of problems that exist in their daily environment. Students are then able to initiate problems that exist in the chemical literacy discourse. In this study, the case that was raised as a topic in the chemical literacy discourse was the case of water pollution. A photo of a polluted river was also presented, which was displayed in front of the class (Pratama et al., 2024).

The series of activities in this first syntax invites students to read, initiate, and record important information in the literacy discourse so that students' chemical literacy and scientific thinking habits will begin to be honed. In addition, cooperation between students to initiate and discuss important information and the ability to initiate existing problems will also develop students' abilities. Figure 1 shows learning activities in the first syntax of the LIRACLE model. The time allocation in the first syntax of the LIRACLE model is 30 minutes.

Figure 2. Implementation of the first LIRACLE syntax

Students are directed to be able to conduct investigations and study chemical concepts in the second syntax. This teaches students to be able to think like scientists and connect chemical concepts in solving a problem. In this study, the chemical concept that can be used to solve water pollution cases is adsorption, which includes the basic concept of adsorption, the concept of adsorbent, the concept of adsorbate, adsorption isotherm, and the role of adsorption in everyday life. The time allocation in the second syntax is 4 x 50 minutes, which is divided into two face-to-face meetings.

The third syntax, LIRACLE learning, invites students to integrate the concept of adsorption that has been learned with the design of problem-solving. Students will try to work together to integrate the chemical concepts that have been obtained into a complete chemical concept. If there is a misconception of the concept, peers in the team will be able to tell the correct chemical concept. If there is a misconception in one group, the lecturer can guide students to the correct concept.

The fourth syntax of the LIRACLE model is filled with the activity of designing an experiment by determining the tools, materials, procedures, data collection sheets, and data analysis. The tools used include a flacon bottle, filter paper, stove, basin, Atomic Absorption Spectroscopy (AAS), filter, and pan, while the materials used include Zeolite sand, distilled water, and Gajah Wong River water samples.

The working steps of the adsorption experiment are to prepare a water sample indicated to be contaminated with Pb metal as much as 1 liter, then boil it to a volume of 20 mL so that it can be put into a flask. The water sample is then analyzed using Atomic Absorption Spectroscopy (AAS) to determine its concentration. Zeolite activation is carried out by washing 200 grams of Zeolite sand with distilled water, then heating it in an oven for about 2 hours at a temperature of 200 °C.

The next step is to conduct an adsorption experiment. Active zeolite is used as an adsorbent in the experiment. A 1-liter sample of Gajah Wong River water is inserted into the adsorption column that has been filled with active zeolite. The tap of the adsorption column is left open so that the water sample that has gone through the adsorption process can come out directly. After that, the water sample is then collected and heated to a volume of 20 mL. The heated water sample is then filtered and put into a flask. The sample is then tested using AAS. The data collection sheet is used to determine the physical characteristics and concentration of the water sample. Table 1 shows the results of the data collection sheet. The data is then processed into a scientific paper to report the results of the study.

Table 1. Data collection sheet

Observation Aspect	**Before Adsorption**	**After Adsorption**
Concentration	0.3340 mg/L	0.1315 mg/L
Colour	Cloudy white	Clear
Smell	Odorless	Odorless

The results of the data collection sheet are then interpreted into a scientific paper. The lecturer has distributed a template to students to make it easier for students to work on it. The template is a general template in journals that includes the title, author name, author affiliation, correspondence contact, abstract, keywords, introduction, methods, results, discussion, conclusions, and bibliography. In the discussion section, it is explained related to the concept of adsorption which can be one solution to Pb metal pollution in water. The explanation of the concept of adsorption in the case of water purification includes: (1) Large Surface Area and Porous Structure: Activated carbon has a large surface area and microscopic pores that allow Fe ions to be easily adsorbed onto the carbon surface. (2) Electrostatic Interaction: Positively charged Pb ions can interact with negatively charged areas on activated carbon, increasing the attraction and adsorption efficiency. (3) Concentration of Pb in Solution: High initial concentration of Pb in solution increases the amount of Pb ions that can be adsorbed until it reaches the maximum capacity of activated zeolite.The selection of active zeolite in powder form affects adsorption including: (1) Larger Surface Area: Crushing increases the surface area, allowing more molecules to be adsorbed. (2) Small Particle Size: Small particles accelerate the adsorption process because molecules reach the adsorbent surface more quickly. (3) More Open Pores: More microscopic pores that are open optimally to capture contaminants. (4) Better Pore Accessibility: Pores are easily accessible, increasing the effectiveness of absorption. (5) Optimal Interaction: Smooth surfaces provide more contact points, strengthening adsorption power. The effectiveness of adsorption (EA) can be determined by Equation 1.

$$\text{EA} = \frac{(C2-C1)}{(C1)} \text{ x } 100\%$$

with description:
EA = effectiveness of adsorption
C1 = concentration before adsorption
C2 = concentration after adsorption
Based on the calculations, the adsorption effectiveness is 60.69%.

The last syntax is related to the part of publishing the scientific paper results that have been made. The classroom atmosphere is guided to resemble a scientific article seminar. Students present their research results in front of the class. After completing the presentation of their research results, the lecturer facilitates students to conduct a question and answer session.

During the presentation and discussion process, students in each group divide themselves into various roles such as presenters, note takers, and question answerers. This clear division of roles is a special characteristic of cooperative learning. This also distinguishes cooperative learning from collaborative learning (Yang, 2023). This scientific discussion activity is recorded in the minutes sheet available in Table 2. After the question and answer session ends, the lecturer corrects if there are misconceptions when students describe their research results. The lecturer also provides reinforcement and suggestions to students.

Table 2. Scientific discussion activity

Asker's initials	Question	Answer
H	Is powdered zeolite efficient as an adsorbent?	Yes, zeolite in powder form has a large surface area so it can increase adsorption capacity.
V	Is there any other way to activate zeolite besides soaking it in distilled water?	There is chemical activation using acids such as HCl

The developed LIRACLE model can be an appropriate learning model in adult learning. In addition, the LIRACLE model can develop chemical literacy skills, get students used to scientific thinking, and train the science process skills of S-1 Chemistry Education students. This will equip students to become professional chemistry teachers in the future.

CONCLUSION

Based on the research that has been conducted, the Literacy and Research-Oriented Cooperative Problem-Based Learning (LIRACLE) model in the case of Gajah Wong River water pollution by Pb Metal has been successfully described from the six syntax models. The first syntax focuses on the initiation of the Gajah Wong River water pollution problem. The second syntax focuses on understanding the concept of adsorption. The third syntax contains activities to integrate the concept of adsorption into the design of solving water pollution problems, the fourth syntax includes the design and implementation of experiments. Based on the experiment, the concept of adsorption can be one solution to overcome water pollution contaminated with Pb metal. The results showed that the sample concentration decreased from 0.3340 mg/L to 0.1315 mg/L, so that the percentage of adsorption effectiveness was 60.69%. The fifth syntax contains the activity of writing a scientific paper with the template provided. The learning activity ends with the sixth syntax, which contains a scientific discussion guided by the lecturer as a moderator. Some questions ask about the long-term effects of the results of the description of the LIRACLE model syntax as a preliminary study in the future development of the LIRACLE model.

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