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RESEARCH PAPER

Environmental Chemistry Course Through Problem-based Learning to Develop Students' Higher-order Thinking Skills and Characters

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Abstract: Students' characters and higher-order thinking skills in environmental chemistry courses are important to develop, because it can make students care about the environment. Environmental chemistry courses are suitable to be taught through a problem-based approach. Problem based learning prepares students to think critically and analytically, to find and use appropriate learning resources. This reseach was a quasi-experimental study with a pre-test post-test design approach. This research aimed at describing the implementation of problem-based learning in environmental chemistry courses and its influence on the development of higher-order thinking skills and students characters. Data were collected with an essay test that demanded higher-order thinking skills and students characters were obtained by inventory. Data were analyzed using ANOVA statistics. It shows that (1) the implementation of problem-based learning in the Environmental Chemistry course was carried out through the stages of concept presentation, presentation of factual problems in various forms, group discussions, and class discussions; (2) implementation of problem-based learning can significantly improve students' higher-order thinking skills and characters; and (3) high-order thinking skills contribute significantly to character development.

Keywords: Problem-based learning, Higher-order thinking skills, Characters

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INTRODUCTION

Science, technology, and pedagogy, especially in the future, develops exponentially demanding the world of education return to its essence, namely education is a process of civilizing and empowering students continuously through Observation-based learning and Collaborative learning-based to emphasize thinking skills at the high impact level on character development [1].

Lewis, A., & Smith, D. [2] explains that higher-order thinking skills include problem-solving abilities, creative thinking abilities, critical thinking abilities, argumentative abilities, and decision-making abilities. Higher-order thinking skills include comprehension, problem solving, critical thinking, and giving practical reasons (pratical reasoning). Understanding is the process of constructing an internal picture of newly entered information. Understanding is related to the interpretation of the meaning or meaning of events, information and phenomena and befits the influence of a stronger direction of thought and action with regard to information that just enters. Higher-order thinking skills are cognitive-level thinking processes that are developed from various concepts, cognitive methods, and learning taxonomies such as problem solving methods. Based on these definitions, higher-level thinking skills include learning skills and learning strategies that used, expressing reasons, thinking creatively and innovatively, making decisions, and solving problems.

Krathwohl [3] explains that the indicators of higher-order thinking skills include (1) analyzing (C4) which is the ability to separate concepts into several components and connect with each other to gain an understanding of the concept as a whole, (2) evaluating (C5) which is the ability to determine the degree of something based on norms, certain criteria or benchmarks, and (3) creating (C6) which is the ability to combine elements into something new,

complete and comprehensive, or make something original.

Critical thinking is the activity of analyzing arguments and bringing insight to each meaning and interpretation, to develop a cohesive and logical pattern of reasoning. Critical thinking is not just looking for answers, but the most important thing is to ask the truth of the answers, facts, or information available. Based on some of the concepts above, in this study, higher order thinking skills are higher level thinking skills that require more complex thought processes that include critical thinking, logical reasoning, systematic thinking, analytical thinking, synthesis thinking, and evaluative, so that they can be used to make decisions in solve problems and form positive attitudes and behaviors (good character) [4].

Character as a way of thinking and behaving is a characteristic of each individual to live and work together in the scope of family, community, nation and state. Good character individuals are individuals who can make decisions and are ready to take responsibility for the consequences of the decisions they make [5]. Suharjana [6] explains that character is a way of thinking, behaving, and acting that characterizes a person and becomes a habit that is displayed in social life. Based on these definitions of character, it can be concluded that the characters contain three key words, namely how to think, behave, and act. Referring to this in the context of this paper, what is meant by character is a way of thinking, behaving, and behaving that characterizes a person's habits in social life. This character will be formed through the way of thinking someone who will lead someone in taking a stand, and the attitude will motivate and encourage an action done consistently and continuously so that it becomes a habit.

Character building can be done through habitualizing ways of thinking and behaving, both in the learning and in the assessment proceses. Good ways of thinking can be formed through the development of high-level thinking skills that can lead to the formation of attitudes, and manifested in the form of good behavior. Hill [7] states that character education determines ways of thinking and behavior. Good character can be an incentive to do good, approve and do good or have noble character.

LeBlanc and Gallavan [8] add character to the affective domain. The opinion of Hill, LeBlanc and Gallavan was extended by Zuchdi [9] that character education is the attitude and behavior that should be carried out towards God Almighty, society, country, nature, and self. Character involves elements of "knowledge, feeling, loving, and acting". Anderson [10] mentions that character is part of the effective sphere consisting of (1) attitudes, (2) interests, (3) values, and (4) self-concepts whose data are collected through observation and self-report methods assuming that those who know the situation someone's affective is himself.

The problem-based learning model starts from presenting problems from the real world as a stimulus that requires students to learn to use a variety of knowledge and requires students to be collaborative, communicative, and cooperative [11]. Rianto [12] states that problem-based learning is a learning model that exposes students to the challenge of "learning to learn". Students actively work together in groups to find solutions to real-world problems. The closer the problem presented to the real world, the better problem-based learning [13].

Widyatiningtyas, et al. [14] report that the results of their research, problem solving instruction show better than expository methods, as well as in terms of student learning activities. The reasoning abilities of students who are given learning with problem-based instruction are better than conventional learning.

Environmental chemistry courses are suitable to be taught through a problem-based approach, because the objectives of this course, in addition to mastering the concepts of environmental chemistry, also the development of attitudes, and behaviors towards various things related to the environment, such as the causes of environmental problems, efforts that can be made to inhibit and fix environmental problems both as individuals and as members of the community [15].

The syntax of problem based learning is (1) Students' orientation to problems; (2) Organizing students; (3) Guiding individual and group investigations; (4) Develop and present results; (5) Analyzing and evaluating the process and results of problem solving (Arends, 2010). Problem Based Learning prepares students to think critically and analytically, and to find and use appropriate learning resources [16].

MATERIALS AND METHODS

This is a pre-experimental research with pre-test post-test design, using a class consisting of 31 students in semester 3 (three), 2019/2020 who program Environmental Chemistry courses with the following distribution.

Table 1. Distribution of study samples by age and gender

Category	Total
Ages 19-20	11 students
Ages 21-22	20 students
Men	5 students
Women	26 students

This research was conducted in the course of environmental chemistry taught by Dr. Wildan, M.Pd. There are 7 main subjects being studied in environmental chemistry courses, namely (1) Ecosystems and natural resources, (2) air pollution, (3) water pollution, (4) soil pollution, (5) waste treatment, (6) tenvironmental issues, and (7) toxicological

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chemistry. Lectures were held in 16 meetings (one semester).

The lecture was divided into two stages. In the first stage (for 7 meetings), the lectures use a conventional approach with lecture method, questions and answers assisted by power point and teaching materials. In the second stage (for 9 meetings), the lectures use a problem based learning model. Learning syntax according to Arends [17] as in table 2 below.

Table 2. Syntax of problem based learning models

Stages	Activities
Student orientation to problems	The teacher conveyed the learning objectives, explains the logistics (materials and tools) needed for problem solving and provides motivation for students to pay attention to problem solving activities.
Organizing students	The teacher helped students define and organize learning so that it is relevant to problem solving.
Guide the investigation	The teacher encouraged students to find appropriate information, conduct experiments, and look for explanations and problem solving.
Present the results	The teacher helped students in the planning and realization of results that are in accordance with the given task.
Analyze and evaluate the process and results of problem solving	The teacher helped students to reflect on the results of their investigations and the learning processes that have been carried out

Syntax was carried out on each subject. The problems given were real problems that occur around students, such as waste problems in West Nusa Tenggara, livestock industry problems that cause global warming, pollution due to microplastics, industrial hazardous waste disposal problems, and forest fires. At each meeting, the three researchers came to observe the ongoing learning activities.

Data collection on learning outcomes of high-level thinking skills and student character was done at the last meeting. The instrument used to measure higher order thinking skills was in the form of a description test, while the students' character was measured using an inventory. The test consists of 5 (five) breakdown questions with stimulus in the form of current environmental facts. Students were asked to answer these questions with the concepts, principles, rules/environmental asaz they have learned. The inventory used to measure student characters consists of 40 statements compiled based on 4 (four) character indicators, namely (1) attitude consisting of 9 items, (2) Interest consists of 10 items, (3) Value consists of 9 items and (4) Self-concept consists of 12 points. The forty points of statement were accompanied by seven alternative answers, namely strongly disagree, disagree, somewhat disagree, quite agree, agree, somewhat agree, and strongly agree.

All evaluation instruments were tested for validation using Pearson's Moment Product correlation while reliability testing using the Spearman-Brown formula. All test items were declared valid with a correlation index ranging from 0.43 to 0.73 with a reliability coefficient of 0.78.

Data analysis was done with the ANOVA test on the scores of high-order thinking skills and character before learning (pre-test) and after learning (post-test) using problem-based learning. ANOVA test was done through the IBM SPSS statistic 22. application.

RESULTS AND DISCUSSION

a. Description of Problem Based Learning

The study of environmental chemistry in this study was carried out in 2 (two) stages. The first stage is to use 7 (seven) meetings with the main goal so that students better understand the basic concepts in environmental chemistry courses as a pre-requisite to attend lectures with a problem based approach. At this stage an outline of all materials on environmental chemistry were discussed by distributing the textbooks that have been prepared by previous researchers with a conventional approach using lecture, question and answer, discussion, and concludes with data collection on student characters with inventory.

In the second stage, students were divided into 6 discussion groups and 6 (six) environmental problems were distributed which were presented in the form of videos, photos, news/writings, policy policies and data relating to environmental problems accompanied by problems or assignments to be discussed either in class that is continued outside the classroom according to the group's agreement. Group discussions were held for 3 (three) meetings, and each group must report the results of group discussions in the form of papers and power points as presentation material in plenary discussions.

During the group discussion, the lecturer team consisting of 2 (people) actively went around and sat down to listen and watch the discussion. Based on the observations of the group discussion nets, the impressions obtained during group discussions, it shows that most students were very active in asking questions, answering friends' questions, and arguing in their groups. During the group discussion, some of the problems were not answered so it continued outside the classroom. When gathering group assignments, 4 (four) groups were able to submit paper assignments and power points on time, others submit assignments at the next meeting. Then there was a class discussion for 3 (three) meetings, at each meeting, 2 (two) groups present their respective group assignments obtained through sweepstakes at the previous meeting, other groups provided input or ask questions.

Based on the observations during class discussions, all groups were very active in responding and defending their opinions based on the references they used, such as books, journals, and papers that they obtained from various sources. After class discussion, the research team provided input on the course of the discussion. At the last meeting, the final exam was conducted with a description form that was similar to the group discussion material and character measurements using an inventory sent via Google forms on each cell.

b. High-Order Thinking Skills Learning Outcomes

Data of High Order Thinking Skills (HOTS) of students were obtained through tests consisting of 5 (five) items of case analysis form. Each item was given a stimulus in the form of pictures/photos, tables, articles and policies related to the environmental problems. In each question, students were assigned to analyze the causes, processes, impacts, and efforts to slow down and/or overcome environmental problems.

From the ANOVA test results, the value of F = 107.245 (Sig.0.000) was obtained. Based on these results, there are differences in the score of pre-test and post-test learning outcomes. The significant difference in learning outcomes was not due to chance, but because of the problem based learning model. The difference in learning outcomes occured because before problem-based learning was carried out, the students have gained knowledge of the concepts, principles, rules and basic principles of environmental chemistry from teaching materials that have been prepared, other sources, and researchers' explanations. This causes when problem-based learning, students already have the initial ability to attend group discussions and class discussions as a means of gaining knowledge and higher-order thinking skills.

From the results of observations during learning, there is a difference in the increase of student activity in group discussions and class discussions. The increased activity is partly because the problems that were used as themes/topics of discussion were the real problems in daily life, so they can be experienced by students. not only that, they were also actively seeking learning resources, because the activeness in the discussion became a material consideration in determining the final value.

This is in accordance with the opinion of Phee [18] which states that the provision of a problem and the process of finding answers in learning can help to be able to more easily remember the material being studied, so students can better understand the material. The same thing was mentioned by Akcay [19] which said that problem-based learning can create learning conditions that are centered on student activity, so students can construct their knowledge and can integrate lessons learned in school everyday life. Belt [20] reveals that problem-based learning can increase student motivation, students can become more independent, reliable problem solvers and have professional skills.

Hmelo-Silver & Barrows [21] states that the problems given in PBL learning do not have a single answer, meaning that students must be involved in exploration with several solution paths. The involvement of students in PBL can help in developing critical thinking skills, fully involved in the learning process through problem solving activities. In this problem-solving activity students are required to be able to develop critical thinking skills as a step to solve the problems discussed and to draw conclusions based on their understanding.

Chen [11] states that problem-based learning is an effective approach to help students grow learning and integrate knowledge and concepts previously learned in the classroom. Activities in problem based learning, students gain creative thinking skills and professional skills. The above opinion is reinforced by the opinion of Echavarria [22], that problem-based learning is a pedagogical strategy that is centered on students by examining problems in daily life and working in teams or groups, thereby being able to train students to be responsible for their own learning and change the role of educators to become facilitators. This is also the same as the opinion of Machingambi [23] that learning motivation is an internal process that exists within a person who gives enthusiasm or enthusiasm in learning, containing efforts to achieve learning goals, where there is an understanding and development of learning.

c. Students Character

Information about the character of students before and after problem-based learning (PBL) is obtained through an inventory consisting of 40 items with alternative answers from 1-7, so the range of theoretical scores ranges from 40-280, with a median of 160.

From the ANOVA test results, the F value is 130,619 (sig. 0,000). These results prove that the difference in the character scores of the pre-test and post-test did not happen by accident, but it occurred because of the influence of an environment-based learning model. Based on these results, it is concluded that problem-based learning in the Environmental Chemistry course can develop students character towards a more positive direction. The character development occurs in all of the components making up the character, namely the attitude component (F = 23,666), interests (F = 15,618), values (F = 15,753) and self-concept (F = 20,828). These results indicate that the components of

the character consisting of attitudes, interests, values, and self-concept are valid as components of character.

According to Torrance [24], a learning model that is oriented to problem solving as in problem-based learning is an effective learning to improve the character of students. The same thing was stated by Nugroho [25] who states that character formation occurs with several stages to change personal character, which starts from dissatisfaction, followed by having a logical and rational vision, being brave to take risks, being responsible until reaching a consistent stage. Problem-based learning can make these stages happen.

Based on the results of post-test data analysis, it was found that the results of high-level learning and student characters obtained a correlation coefficient (ryx) of 0.729 with a coefficient of determination (ryx) 2 of 0.532 through the regression equation Y = -15.049 + 2.707X. Thus 53.2 percent of the students' character after attending environmental chemistry learning with a problem-based approach was contributed by high-level learning outcomes. These results are in line with the results of Martawijaya's [26] study which reported that there was a significant relationship between higher-order thinking skills and student character. The relationship between HOTS and student character is caused by one's ability to see, observe, predict, think, guess, consider, assess, and solve problems will affect moral development in him. The better one's thinking ability, the more likely it is to have good moral development, and vice versa.

CONCLUSION

Based on the data analysis, it indicates that the implementation of problem-based learning in the Environmental Chemistry course with the stages of concept presentation, problem presentation, group discussion, class discussion, can take place well and increases the student activities in learning. Problem-based learning in Environmental Chemistry courses can improve high-order thinking skills and develop student character. High-order thinking skills contribute significantly to character development.

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