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Teacher's perceptions on the development of *Clitoria ternatea* extracts as a learning media to enhance students' scientific creativity

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ABSTRACT

The advancement of the industrial revolution era has made scientific creativity an essential skill for students. Scientific creativity can be cultivated using educational media. This study aims to describe chemistry teachers' perceptions regarding the development of natural indicators from butterfly pea flower (*Clitoria ternatea*) extract as a learning medium to enhance scientific creativity. This research employs a mixed-method approach with a Sequential Explanatory Design involving 21 chemistry teacher respondents in Bandar Lampung. The results indicate that all respondents positively perceive the development of natural indicators from *Clitoria ternatea* extract as a learning medium to enhance scientific creativity, considering it accurate, easy to use, and environmentally friendly. Therefore, the developed natural indicator can be used as a learning medium to enhance students' scientific creativity. The implications of this study highlight the potential use of environmentally friendly natural indicators in educational practices to foster scientific creativity among students.

Persepsi guru terhadap pengembangan indikator dari ekstrak *Bunga telang* sebagai media pembelajaran untuk meningkatkan kreativitas ilmiah siswa

Kata Kunci:

Ekstrak *Bunga telang*
Limbah deterjen
Media pembelajaran
Indikator alami
Kreativitas ilmiah

ABSTRAK

Kemajuan era revolusi industri menjadikan kreativitas ilmiah sebagai keterampilan yang penting dimiliki siswa. Kreativitas ilmiah dapat dilatih menggunakan bantuan media pembelajaran. Penelitian ini bertujuan untuk mendeskripsikan persepsi guru kimia mengenai pengembangan indikator alami dari ekstrak bunga telang (*Clitoria ternatea*) sebagai media pembelajaran untuk meningkatkan kreativitas ilmiah. Penelitian ini menggunakan metode campuran dengan *Sequential Explanatory Design*, melibatkan 21 responden guru kimia di Bandar Lampung. Hasil penelitian menunjukkan, seluruh responden memiliki persepsi positif terhadap pengembangan indikator alami ekstrak *Clitoria ternatea* sebagai media pembelajaran dalam meningkatkan kreativitas ilmiah karena dianggap akurat, mudah digunakan, dan ramah lingkungan. Dengan demikian, indikator alami yang dikembangkan dapat digunakan sebagai media pembelajaran dalam meningkatkan kreativitas ilmiah siswa. Implikasi dari penelitian ini menyoroti potensi penggunaan indikator alami yang ramah lingkungan dalam praktik pendidikan untuk menumbuhkan kreativitas ilmiah di kalangan siswa.

1. INTRODUCTION

The development and progress of the Industrial Revolution era 4.0, which is full of challenges in the global economic climate, makes innovation and creativity an essential skill for students [1]. Creativity is vital to develop and enhance to help learners solve future or current problems [2], [3]. Creativity in each domain of science is different [4], [5]. Creativity in science means achieving new and unique steps in realizing the goals of science itself, namely knowledge about the world or the surrounding environment [6]. In solving problems related to the application of science, students must be able to explore their abilities, imagine various ways to find solutions and create new combinations of knowledge or problem-solving techniques [7]. As a result of the relationship between science and creativity, the term scientific creativity emerged [8].

Scientific creativity is the skill of generating new ideas or products that are relevant to the context and have scientific usefulness [9], [10]. Scientific creativity is different from other creativity because it involves scientific experiments, discoveries, and problem-solving that are creative and active in scientific activities [11]. Scientific creativity is believed to be a key factor in tackling increasingly complex real-life problems [12].

The results of the scientific creativity profile test of students in Indonesia obtained an achievement of 49.15%, which shows that achievement is still low [13]. One of the causes of the low scientific creativity of students comes from the implementation of learning that still applies conventional methods, where learning activities are still centered on teachers and students tend to be passive [14]. The habit of students memorizing learning material and lack of learning involving scientific processes results in students' difficulty understanding in applying the concepts of the material that have been obtained to deal with problems in everyday life that require creative thinking and problem-solving [15].

Efforts can be made to increase students' scientific creativity by applying problem-based learning [16]. Problem-based learning makes students challenged to work with group members to solve problems and find creative solutions to existing problems [17]. Some research results show that problem-based learning can improve scientific creativity and student learning outcomes [18], [19].

Fundamental problems in everyday life can be in the form of environmental pollution problems caused by various types of waste, such as detergent waste. Detergent waste is a common waste produced by household activities. Detergent waste is included in hazardous and toxic materials because it contains chemicals such as surfactants (15-25%), builders, fillers, and additives [20]. The quality analysis parameters of detergent waste used refer to Permen LHK Nomor 68 Tahun 2016 about the quality standards of domestic waste, one of them is seen from the Potential Hydrogen (pH). Potential Hydrogen (pH) detergent waste is approximately ranging from 10-12, while the pH that the environment can tolerate is 6-9 [21], [22].

The pH determination technique in detergent waste can be applied in chemistry subjects in high school on acid-base titration material. However, in learning acid-base titration, a learning media in the form of indicators is needed to determine the end of the titration process. Indicators may cause different color changes according to the pH state of the tested sample [23]. Indicators widely used in practicum activities in schools are synthetic indicators such as litmus paper, universal indicator paper, phenolphthalein, methyl red, and bromothymol blue [24]. Synthetic indicators have limitations such as causing environmental pollution, high availability and production costs, and their relatively expensive price [25]. One way to overcome this problem is to use natural indicators derived from plant pigments from flowers, leaves, fruits, or fruit peels [26].

Some research results point to extracts from natural products. Corresponding pKa, which have been identified as natural indicators for acid-base titration, such as dragon fruit peel with a pKa value 7,33-9,33 [27], onion peel with a pKa value 8-9 [28], bougainvillea with a pKa value 7-10 [29], and mangosteen peel with a pKa value 6,2-8,2 [30]. Each plant extract has a different pKa value, with differences in pKa values when testing acid or base solutions using indicators from different plant extracts. The color changes that occur are not the same. One other type of plant that has the potential to be used as a natural indicator is the *Clitoria ternatea*, with a pKa value of 4-10 [31]. *Clitoria ternatea*, as a natural indicator in acid-base titration, has been widely used [32]-[34]. However, the characteristics of *Clitoria ternatea* in each region are different, for example, in terms of morphology and flavonoid levels [35]. Some factors affect these differences, including climate, sun exposure, and altitude of a place [36]. The difference in the characteristics of *Clitoria ternatea* in each region affects the pKa value and pH range of *Clitoria ternatea* extract as an indicator [37]. Therefore, it is necessary to develop acid-base indicators of striped flowers to the region's conditions, especially in Bandar Lampung City.

Therefore, this study aims to describe teachers' perceptions of the development of natural indicators of *Clitoria ternatea* extract as a learning media in detergent waste problem-based learning to increase students' scientific creativity. This is because the learning media used is *Clitoria ternatea* extract, which is easily found in the surrounding environment and used in detergent waste problem-based learning, which phenomenon can be observed by students in everyday life so that students' scientific creativity is trained in solving problems in the surrounding environment by utilizing natural tools and materials that are easy to find. Thus, it is hoped that learning will be meaningful and the understanding of concepts obtained can be used by students in overcoming problems that exist in real life.

Contribution to the literature

This research contributes to:

- Providing innovation in science education by introducing *Clitoria ternatea* extract as a natural indicator.
- Enhancing scientific creativity by incorporating problem-based learning with real-life environmental issues like detergent waste.
- Offering empirical evidence on teacher perceptions, showing positive acceptance of natural indicators in chemistry education.
- Supporting sustainable practices in education by promoting the use of locally available, environmentally friendly materials

2. METHOD

This research was conducted in public and private high schools in Bandar Lampung City for the 2022/2023 academic year. The research method used is mixed, and the strategy used is a Sequential Explanatory Design by combining qualitative and quantitative data collection and data analysis. The data collection techniques used were interviews and questionnaires. Interviews were conducted with seven respondents of chemistry teachers, and questionnaires were distributed to 21 respondents of high school chemistry teachers in Bandar Lampung city. The scheme of the research design can be seen in Figure 1.

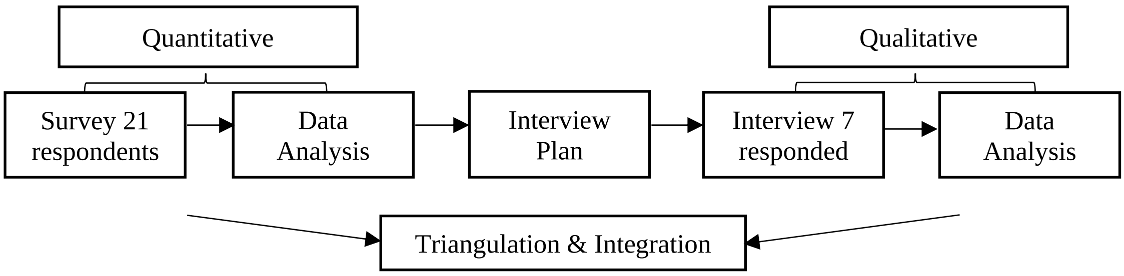

Figure 1. The Schematic Research Design

Based on the Sequential Explanatory Design scheme above, the research starts with quantitative research and continues with qualitative research that follows the explanatory strategy. The instruments used in this study were by using questionnaires and interview guidelines. The first data collection technique was carried out through the distribution of questionnaires to teachers with a Google form, which aimed to determine teacher perceptions of the development of natural indicators of *Clitoria ternatea* extract as a learning media in detergent waste problem-based learning to increase students' scientific creativity. The questionnaire given to teacher respondents consisted of three indicators: learning methods and models used in chemistry learning, acid-base indicators, and scientific creativity. Furthermore, an analysis of the questionnaire results was carried out, which was described in percentage form. The questionnaire uses the Guttman scale, which has answer choices according to the content of the question, namely: "Yes" and "No" with scores of "1" and "0" [38]. After the data is analyzed, it is verified through the interview's completeness. Interviews were conducted to determine the learning methods and models, acid-base indicators, and scientific creativity. Qualitative and quantitative data analysis is carried out in an integrated and triangulated manner.

The data obtained is analyzed by classifying it, tabulating it based on the classification made, and calculating the percentage of answers using the following formula [39].

$$\%Jin = \frac{\sum Ji}{N} \times 100\,\% \qquad (1)$$

Where $\% J_{in}$ is the percentage of choice answer i, $\sum J_i$ is the number of respondents who answer i, and N is the number of all respondents.

3. RESULTS AND DISCUSSION

Table 1 shows the results of interviews and questionnaire distribution to chemistry teachers of public and private high schools in Bandar Lampung City.

Table 1. Results of Interpretation of Teacher's Perception Questionnaire

No	Description	Answer (%)	
		Yes	No
1	Do you think creativity is one of the most important skills for students in the era of Revolution 4.0?	100%	0%
2	Have you ever exercised students' creativity in learning?	0%	100%
3	Scientific creativity is different from other general creativity. Do you know the difference?	35%	65%
4	Have you ever trained students' scientific creativity in learning?	0%	100%
5	Do you think it is necessary to use real problems from everyday life to learn, especially in acid-base titration?	100%	0%
6	Is your acid-base titration learning based on fundamental problems in everyday life?	0%	100%

7	Have you ever connected the problem related to detergent waste with learning acid-base titration?	0%	100%
8	Do you think learning acid-base titration that connects with problems related to detergent waste can increase students' scientific creativity?	100%	0%
9	Have you ever been with students at school doing acid-base titration practicum?	50%	50%
10	What are the natural indicators that you use during acid-base titration practicum?	10%	85%
11	Do you agree that synthesis indicators are replaced with natural indicators from plant extracts?	100%	0%
12	Have you ever developed natural indicators of plant extracts for acid-base titration practicum?	0%	100%
13	Have you ever used *Clitoria ternatea* extract as an acid-base indicator?	15%	85%
14	Are you interested in using *Clitoria ternatea* extract to indicate acid-base titration?	100%	0%
15	Do you agree if researchers plan to develop acid-base indicators from *Clitoria ternatea* extract?	100%	0%

Based on Table 1, it can be seen that all teacher respondents responded that creativity is one of the essential skills for students in the era of the Industrial Revolution 4.0. They assume that with creativity, students can provide ideas or practical solutions to problems. However, all teacher respondents have never trained students in scientific creativity in learning. This is because some teachers do not know the difference between scientific creativity and other general creativity. In addition, teacher respondents consider that training scientific creativity in learning requires a long time, so the learning that has been carried out is more focused on completing the target material.

All teacher respondents responded that using real problems in everyday learning in learning was necessary, especially in learning chemistry acid-base titration material. This is so that the learning obtained by students can be helpful and meaningful in student life. However, all teacher respondents have not applied real problem-based learning in learning acid-base titration. This is because problem-based learning requires a long time and teachers feel less confident in implementing problems that are by acid-base titration learning. Teachers also find it difficult to determine real problems caused by the material to be studied. As many as 90% of teacher respondents have never applied problem-based learning related to detergent waste in learning acid-base titration.

Acid-base titration practicum activities are only done by 50% of school teacher respondents. This is due to constraints on the availability of practicum facilities in schools, including outdated materials, unavailable practicum equipment, and laboratories widely used as classrooms or teachers' offices. As many as 85% of teacher respondents still use synthetic indicators in acid-base titration practicum activities. The use of synthetic indicators is still used in schools due to a lack of reference and understanding of making correct natural indicators. In addition, the synthetic indicator that is generally used is phenolphthalein because it is considered more practical and has also been available in school laboratories. However, as many as 95% of teacher respondents agreed to use natural indicators from plant extracts as a substitute for synthetic indicators in practicum activities because they were considered more environmentally friendly. All teachers have never developed natural indicators from plant extracts and 85% of teacher respondents have never used *Clitoria ternatea* extract as an acid-base indicator.

The following is data from interviews conducted with chemistry teachers from different high schools in Bandar Lampung City. The interviews were conducted to find out teachers' perceptions of the methods and models used in chemistry learning, knowledge of students' scientific creativity, and acid-base indicators used in schools.

3.1 Teachers' Perceptions of the Learning Methods and Models Used

Data collected through questionnaires shows that many teacher respondents have never used problem-based learning in chemistry, especially acid-base titration. In this interview, we will explore the methods and models used by teachers further.

Teacher respondent 1 stated: "*I use lectures, discussions, and practice. In my opinion, if chemistry learning only understood from the explanation from the teacher, it will result in students becoming passive and students are not interested in following class lessons. So I use the lecture and discussion method to improve their ability to solve the problems given. I have never used a problem-based learning model including the problem of detergent waste in chemistry learning. Using a learning model, it takes a long time to complete a chapter of material because students feel confused and have difficulty following the learning process.*"

Teacher respondent 2 stated: "*I use the lecturing, discussions, and practicum methods because it makes the classroom atmosphere livelier and students become more active. I usually use the discovery learning model on acid-base titration materials because, in my opinion, discovery learning syntax is easy to apply and time-efficient. However, I have never used a problem-based learning model in learning acid-base titration, because I don't understand the problems that are by the related material. So, I have never used the problem of detergent waste in learning.*"

Teacher respondent 3 stated: "*In learning chemistry, I chose the lecture method, because this method is easy to implement and practical. If it is not explained, students will be confused and do not understand, so I prefer to use the lecture method. After I explain the material, I will give students practice questions contained in printed books or LKS from publishers. I have never used any learning model in chemistry learning including acid-base titration because using the learning model will take a long time by applying the syntax of the learning model. I also never use the problem of detergent waste in chemistry learning.*"

Teacher respondent 4 stated: "*The learning methods I use in learning chemistry are lecture methods, practicum, and practice. I have never used any learning model in chemistry learning, because if you use a learning model it will make the delivery of material longer so that in one semester not all material can be delivered. I never use the problem of detergent waste in learning, usually, I go directly into the material to speed up the time of delivery of the subject matter.*"

Based on the interview results, the findings were that many teacher respondents still used the lecture method. As a result, students become bored during learning, and not infrequently, they do not pay attention to explanations from their teachers and feel sleepy when learning chemistry. The lecture method learning process tends to be centered on the teacher, not the learners [40]. Step activities in the lecture method that are not combined with other models or techniques make students passive so that asking questions or responding to material does not occur. In addition to being passive, learners cannot develop what is in their minds about a material. So that students' scientific creativity is not trained during learning [41].

The learning model that teacher respondents have used is generally discovery learning rather than problem-based learning models for the reason that discovery learning syntaxes are easy to apply and efficient in terms of time. However, most teachers find it difficult to explain when asked about what phenomena are usually displayed when using discovery learning models. Indeed, when viewed from the syntax of the discovery learning model and the problem-based learning model, both models are the same, starting with providing stimulation in the form of phenomena in everyday life to stimulate students in thinking about the material to be learned. In addition, some teachers still do not use any learning model even though they use the 2013 curriculum for reasons of time efficiency because if they apply the learning model, it becomes longer.

3.2 Teachers' Perceptions of Students' Scientific Creativity

Based on data collected through questionnaires, most respondents do not know about scientific creativity. To find out more, an interview was conducted.

Teacher respondent 1 stated: *"I know about creativity but I just heard the term scientific creativity. As far as I understand when training creativity to students, later students will create a product at the end of learning. I also don't know the indicators of scientific creativity. I have never trained students' scientific creativity or applied it to learning models or other learning media. I also don't know how to train students' scientific creativity. I agree that creativity is important to be trained in students because the ever-evolving times require creativity and innovation so that students will not be left behind by the progress of the times."*

Teacher respondent 2 stated, "*I just know the term scientific creativity, and I don't know the indicators yet. I have never trained scientific creativity in students and do not know how to exercise it. I agree that it is necessary to train creativity in students so that when dealing with real problems around their environment, students can use the concepts of the material that have been obtained to overcome these problems."*

Teacher respondent 3 stated: *"I don't know about scientific creativity and its indicators and don't know how to improve students' scientific creativity. I agree it is necessary to practice creativity so that students can compete with the development of other countries' progress."*

Teacher respondent 4 stated: *"I already know the term scientific creativity but it has never been applied in learning. Scientific creativity that I know that in the learning process, students will later carry out scientific processes such as observing a phenomenon, and doing practicum activities to get a concept of material without being told directly by the teacher. But so far, the learning I have done emphasizes cognitive aspects rather than skills for time efficiency. I agree that it is necessary to level student creativity so that students can keep up with the times that require innovation to be competitive."*

Based on the interview results, the findings were that most teacher respondents did not know about students' scientific creativity and considered that scientific creativity was the same as creativity in general. Scientific creativity is the skill to generate new ideas or products relevant to the context and have scientific usefulness [9], [10]. Scientific creativity differs from other creativity because it deals with scientific experiments, discoveries, and creative problem-solving that are active in scientific activities [11]. According to all teacher respondents, increasing students' scientific creativity is necessary.

3.3 Teachers' Perceptions of Acid-Base Indicators

Based on data collection through questionnaires, it can be seen that most respondents have not used natural indicators in acid-base titration. To find out more, an interview was conducted.

Teacher respondent 1 stated, *" If I am doing acid-base titration practicum, I use a synthetic indicator that is already available in the school laboratory, namely phenolphthalein. I have never used natural indicators of plant extracts because I don't know how to make them yet."*

Teacher respondent 2 stated: *"I always use a synthetic indicator, phenolphthalein, in learning acid-base titration because it is more practical. I have never tried to make natural indicators from plant extracts due to a lack of references to how they are made."*

Teacher respondent 3 stated, *"I always use phenolphthalein during acid-base titration practicum because it is practical and available in the laboratory. I have never tried to make a natural indicator from plant extracts and just knew of the existence of Clitoria ternatea that can be used as a natural indicator."*

Teacher respondent 4 stated: *"If I am going to do an acid-base titration practicum, I use a synthesis indicator, phenolphthalein. I once used natural indicators from Clitoria ternatea extract as indicators on acid-base material instead of acid-base titration material. But I also don't know the procedure for making natural indicators of the actual extract of Clitoria ternatea."*

Based on the interview results, the findings were that all teacher respondents still used synthetic indicators, generally phenolphthalein, during practicum at school. This is considered more practical and is already available in school laboratories. All respondents had never made a natural indicator due to a lack of understanding of the manufacturing process. Synthetic indicators have limitations such as causing environmental pollution, high availability, and production costs, and the price is relatively expensive [25]. One way to overcome this problem is to use natural indicators derived from plant pigments from flowers, leaves, fruits, or fruit peels [26]. This is supported based on the research results [42], [43], which state that synthetic acid-base indicators require higher costs and ordering from chemical distributors in specific quantities. Alternative acid-base indicators from plant pigments around the environment are essential so that economic costs can be reduced and the availability of materials faster [44]. This is supported based one theory, which states that there are several indicators in supporting learning using media consisting of five things, namely the relevance or suitability of learning media to learning objectives and student characteristics, the ability of teachers to utilize learning media so that it is easier to deliver material to students, ease of use of learning media in its operation, availability means the facilities and infrastructure owned by the school. Usefulness means that learning media must have use value that benefits students' understanding of the material [45]. Other studies supporting this research's findings reveal that using instructional media can enhance students' scientific creativity [46]. According to all respondents, it is necessary to develop natural indicators of *Clitoria ternatea* extract as a learning media because it is considered more environmentally friendly and easy to find.

The natural indicator extracted from *Clitoria ternatea* needs to be developed as a learning medium to enhance students' scientific creativity, as it can benefit students in the current era of globalization. This research emphasizes innovative learning media's importance in improving students' skills. It provides recommendations for future researchers to test the effectiveness of this natural indicator to determine the level of success achieved from a learning medium by the planned learning objectives. The aim is to expand the understanding of its application and benefits in education.

4. CONCLUSION

Based on the research results and discussions, many teacher respondents still apply the lecturing method in teaching chemistry. About 65% of the teacher respondents are not yet aware of the difference between scientific creativity and other types of creativity. All teacher respondents have never used real-world problems, such as the detergent waste issue in the rivers of Bandar Lampung City, in their chemistry teaching. None of the teacher respondents have ever trained students in scientific creativity. Additionally, 85% of the teacher respondents still use synthetic indicators in practical activities at school. Based on the overall results of the questionnaires and interviews conducted with chemistry teachers, all respondents positively perceive the development of natural indicators from *Clitoria ternatea* extract as a teaching medium to enhance scientific creativity because it is considered accurate, easy to use, and environmentally friendly. The implications of this research can serve as input for teachers to utilize alternative teaching media in the form of natural indicators in high school chemistry experiments that are accurate, safe, and easy to obtain. Furthermore, teachers can utiliZE *Clitoria ternatea* as the potential resources available in their respective regions as teaching media to enhance students' scientific creativity.

AUTHOR CONTRIBUTION STATEMENT

NWPK contributed to conceiving and designing research, conducting research, analyzing and interpreting data, and writing articles. NF contributed to improving and providing input on the research manuscript. CD contributes to improving and providing input on the research manuscript.

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