



# Journal of Educational Sciences

Journal homepage: <https://jes.ejournal.unri.ac.id/index.php/JES>



P-ISSN  
2581-1657

E-ISSN  
2581-2203

## Feasibility Analysis of PBL Model to Build Student Creativity in Determining pH Route of Natural Indicator

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### ARTICLE INFO

#### Article history:

Received: 17 Jan 2022

Revised: 23 Sept 2022

Accepted: 27 Sept 2022

Published online: 24 Oct 2022

#### Keywords:

Design

Learning

PBL

Creativity

### ABSTRACT

Education in the industrial era 4.0 must be adapted to the characteristics and skills of students demanded in the 21st century, one of the skills required is creativity. The data shows that the creativity of students in schools is still relatively low. Learning design must be designed to be able to build student's creativity. This study aims to analyze the feasibility of the Problem Based Learning (PBL) model to build student creativity in determining pH route of natural indicator. The method used in this research is descriptive with DbR design. DbR consists of 4 stages, problem identification and analysis, development prototype, testing and implementation, and reflection. This research was conducted only at the limited trial stage to see the feasibility of the Learning Design using the PBL model to build student creativity. The instruments used in this study were internal feasibility test sheets, external feasibility test sheets, TCOF, and creativity observation sheets. The results showed that the learning design with the PBL model is categorized as very feasible based on internal, external, and TCOF feasibility tests to develop student creativity and student creativity is categorized very well through learning using the PBL model.

## 1. Introduction

Education is one of the human needs so that the quality needs to be improved. The quality of education, as one of the pillars of meaningful human resource development, is very important for national development. It can even be said that the future of the nation lies in the existence of quality education that takes place in the present (Alkhaf, 2020). A nation and a country is largely determined by the progress of qualified and competitive human resources (HR). To prepare qualified and competitive human resources, strategic means are needed, one of which is education. Education in the industrial era 4.0 must adapt to the characteristics and skills of students in the 21st century (Yusuf & Asrifan, 2020).

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Doi: <https://doi.org/10.31258/jes.6.4.p.590-602>

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Some of the skills that must be developed are creativity, problem solving, and information technology and media literacy. Creativity is one of the points emphasized in the NGSS (NGSS 2013). Therefore, if teachers want to improve their students' ability to acquire scientific views, creativity must be integrated into the science classroom (Shanahan & Nieswandt, 2009). According to Hu and Adey (in Demirhan & Şahin, 2019), scientific creativity is an intellectual ability or trait that produces or has the potential to produce certain products that are original and have social or personal value for certain purposes. The need for these skills makes students have to undergo learning related to these skills in the learning environment.

However, the data in the field shows that the creativity index in Indonesia is still relatively low. Indonesia is ranked 115th out of 139 countries based on data on the Global Creativity Index (Florida, Melander, & King, 2015). The data also shows that students' creativity in schools is still relatively low based on the Recapitulation of Test Result Data Based on Creativity Indicators where the achievements for the indicators of flexibility, originality, elaboration, fluency are 67.08%, 67.91%, 71.11%, respectively, and 59% which based on the interpretation of this value is still relatively low (Lubis, 2018). Based on these data, the teacher as the designer of the learning environment must be able to create an environment to build and increase student creativity, especially in learning science (Akaygun & Aslan-Tutak, 2016).

So far, in the learning process in schools, students are not given the opportunity to think about and develop their potential which results in low student creativity (Kenedi, 2017). Wahyu (2019) also stated that currently education in Indonesia is still lacking in developing students' creativity, while creativity is important to support learning (Wahyu, Suryatna & Amalia, 2019). Of course, creativity should be trained and empowered optimally, so efforts are needed to provide debriefing to students by teachers. The implementation of creativity is also one of the skills that must be developed in the 2013 curriculum, namely developing creativity by paying attention to the morals and values of Pancasila and living in a society (Kemendikbud, 2013).

Creativity is not only a demand in general, but creativity in particular is also demanded in chemistry learning. Creativity in learning chemistry is very important. One of them is the experiment of teaching chemistry in the context of media and methods. Creativity in this field means formulating hypotheses, then planning, implementing, reflecting and, if necessary, revising experiments (Newton, 2009). According to Sawyer (2012) critical evaluation of subsequent results is also a creative process. To develop creativity can also promote problem solving skills and transfer of knowledge, because knowledge must be applied to new situations. Thus, it can also encourage creativity and stimulate creativity to solve the problem (Semmler, Uchinokura & Pietzner, 2018). Education is seen to be able to develop the creativity of students. This study aims to see the feasibility of learning design using the PBL model to develop students' creativity in determining the natural pH indicator tray made from leaves.

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## 2. Methodology

The method used in this research is descriptive evaluative method with Design-based Research (DbR) design. DbR is a systematic study of designing, developing and evaluating educational interventions such as programmes, strategies and learning materials, products and systems as solutions for solving complex problems in educational practice, with the aim of advancing our knowledge of the characteristics of these interventions and the process its design and development (Plomp et al, 2007). This study involved several research participants. The PBL model internal feasibility test involved 3 experts and 3 chemistry teachers. The external feasibility test (limited trial) involved 22 class XII students in a high school in Pekanbaru and for TCOF observation, this study involved 3 observers. The instruments used in this study were internal feasibility test sheets, external feasibility test sheets, TCOF, and creativity observation sheets. The internal feasibility test in this study is a test of the suitability of learning activities at the PBL model stage with creativity sub-indicators. The scoring and percentage score categories on the internal feasibility test sheet are in accordance with Riduwan (2015). The external feasibility test in this study was a learning model implementation sheet, namely the implementation of activities in learning obtained through observation techniques using a rating scale. The TCOF instrument used in this study was adapted from the journal Teaching for Creativity by Science Teachers in Grades 5–10 written by Nasser S. Al-Abdali & Sulaiman M. Al-Balushi (2016). Processing of data from observations of student creativity is processed according to the categories compiled by Sugiyanto, Masykuri, & Muzzazinah (2018).

## 3. Results and Discussion

### *Internal Feasibility of Learning Design Using the PBL Model*

The percentage of suitability scores between learning activities at each stage of the PBL model with the creativity sub-indicator has the highest score at the stage of orienting students to problems, which is 94.91% (very strong category). The lowest score was at the stage of guiding individual and group investigations and developing and presenting results, which were 93.91 and 93.45%, respectively, in the very strong category. The percentage of the average suitability score of the creativity sub-indicator at each stage of the PBL model is presented in Figure 1.

Based on Figure 1, it can be seen that the percentage of suitability of learning activities at each stage of the PBL model with creativity indicators on average has a very strong category. The learning activities designed by the researcher are in accordance with the activities from the stage of orienting students to the problems proposed by Hmelo & Silver (2004) where in the PBL model the teacher acts as a facilitator to guide student learning through the learning cycle. In the early stages of the PBL model, the researcher presented a discourse on the LKPD. Through the discourse presented, it is hoped that students can understand the problems indicated by the ability to provide various kinds of interpretations of an image,

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story, information, or problem, ask questions and their own ideas smoothly. By understanding the problem, students can think of various ways to solve a problem by looking for a deeper meaning to the answer or solving the problem with detailed steps. This ability is a sub-indicator of creativity to be achieved through the PBL model used in learning design. This is in accordance with the theory put forward by Tan (2009) that creativity is included in several abilities needed when solving and analyzing problems. In the PBL model applied in this study, students were also asked to design the manufacture of natural indicators from leaves to develop students' creativity. Learning that aims to develop creativity involves instructional strategies that encourage students to think and act creatively (Agustin et al, 2021). Discussion activities at the end of the lesson are expected to be a means to develop students' creativity in seeing the weaknesses and strengths of the natural indicators made by each group, provide rational reasons that can be accounted for to reach a decision taken by the group, provide considerations, and analyze the process. problem solving.

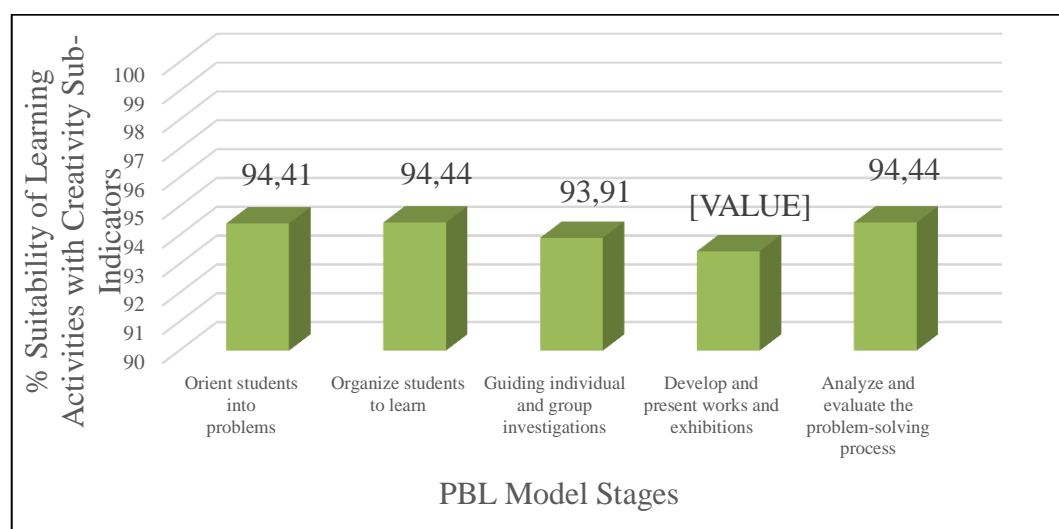


Figure 1. PBL Model Internal Feasibility Test Results to Develop Student Creativity

### ***External Feasibility of Learning Design Using the PBL Model***

The external feasibility of the learning design in this study was seen from the implementation of learning activities in the PBL model to develop the creativity of students. The percentage of learning implementation at each stage of the PBL model is presented in the following figure:

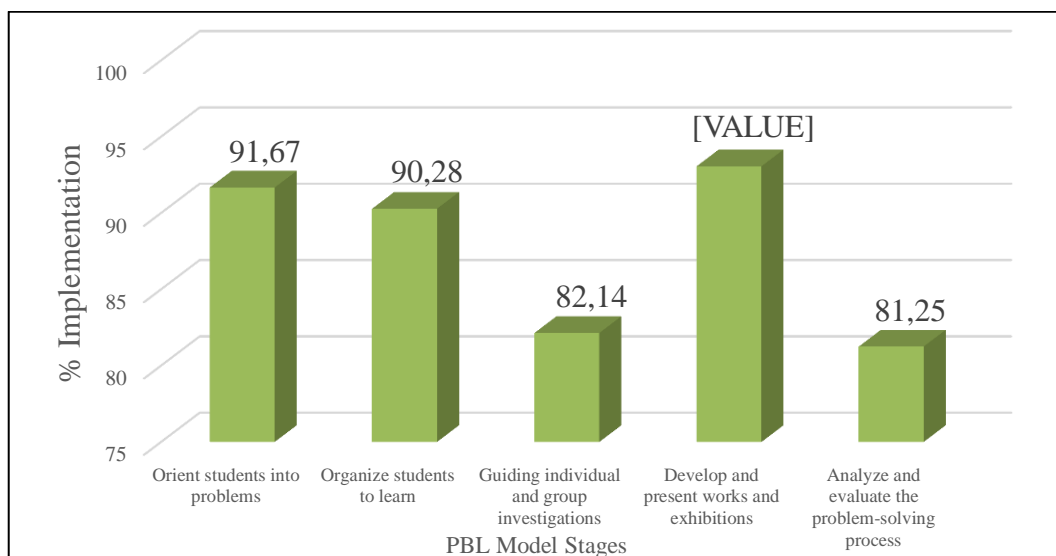


Figure 2. PBL Model Internal Feasibility Test Results to Develop Student Creativity

Based on the results of observations, it was found that the activities at the stage of orienting students to problems were carried out very well. At the beginning of the activity, the researcher provided a Google Drive link so that students could download the LKPD. Researchers also give time for students to understand the contents of the LKPD thoroughly and provide opportunities for students to ask questions about parts of the LKPD that are not understood by students so that the next learning process runs smoothly. Furthermore, students are asked to state the problems found in the LKPD and put forward the initial solutions proposed to solve the problems found. Students are very enthusiastic in expressing their opinions. Some students also complete the answers from their friends. The results of the observations showed that the learning activities at the stage of organizing students to learn were carried out very well. At this stage, students are asked to consider the problem-solving plan (initial solution) proposed at the previous learning stage. The researcher asked the students to study further whether the proposed solution was in accordance with the relevant chemical theory by referring to several literatures such as books and journals. This activity is carried out so that students can learn independently and find their own knowledge. This activity is carried out at home. The researcher also provides a WhatsApp group as a medium for class discussion if students want to ask questions that are not understood. To make learning more memorable, the researcher asked students to record every important point that was learned independently at home. The researcher also asked students to write down individual answers to the questions contained in the LKPD. This is done so that every student is active in learning. Learning activities at the stage of guiding individual and group investigations were carried out well but had a lower percentage than the three stages of learning with other PBL models. At this stage the researcher divided the students into 4 groups. Based on the groups that have been distributed, the researcher asks students to share the knowledge that has been learned in the previous learning stages. Students also discuss with each other about the results of problem solving

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that has been done individually and discuss tools, materials, and procedures that will be used in making natural indicators. Researchers also asked students to re-check the suitability of problem solving and experimental procedures that have been determined with the relevant chemical theory.

At this stage the researcher asked students to simulate the manufacture of natural indicators, but only a part of the group of students did simulations of making natural indicators. There are still groups of students who do not perform simulations so that learning activities are not carried out optimally, this is because students are convinced that the leaves used as the main ingredients in making natural indicators can be used as acid-base indicators because the leaves chosen by students have very striking colors. For the group conducting the simulation, the researcher guides the students to evaluate the results of the simulation that has been carried out. If there are deficiencies or errors in the simulation, students are asked to look at alternative solutions and alternative materials or other procedures that can be used in making natural indicators.

The fourth stage of learning in the PBL model is developing and presenting the work. Learning activities at this stage were carried out very well. At this stage, students conduct experiments based on the results of group agreement during the discussion. In conducting experiments, students were asked to record important variables observed during the experiment, such as the color of the natural indicator that had been made and the color changes that occurred when the natural indicator was dropped in a solution with a pH of 1-14. The researcher also asked the students to record the results of the experiments that had been carried out in the LKPD. The results of the experiments carried out by the students were also compiled in the form of an experimental report. Presentation activities are also carried out at this learning stage. Students are asked to present the results of the experiments that have been carried out. The power point presented by students is equipped with pictures. The presentation of an attractive power point made other students who were listening more enthusiastic in paying attention to the presentation at the google meeting.

Learning activities at the stage of analyzing and evaluating the problem-solving process were carried out well but the percentage of implementation of learning activities at the stage of analyzing and evaluating the problem-solving process had the lowest score compared to the previous PBL stages. Researchers provide opportunities for students to ask questions to groups that have presented the results of solving problems and the results of experiments that have been carried out. The researcher also asked students to discuss and consider the solutions presented by each group. The students were very enthusiastic about asking questions, so the researcher limited the questions given to 1 question per group. If there were other questions, the researcher asked the students to write down these questions and submit them to the presenters to be answered by the presenters outside of class hours. After the question-and-answer session, the researcher provided confirmation of the learning material, the results of problem solving, and the results of experiments that had been carried out by the students.

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### ***Feasibility of Learning Design Using PBL Model Based on TCOF***

The feasibility of the learning design was analyzed per stage of the PBL model and per category. The TCOF sheet was filled out by 3 observers during the learning design implementation process. The results of the TCOF analysis per PBL stage and per category can be seen in Table 1 below

Table 1. TCOF Results per PBL Stage and for Each Category

TCOF Category	Score of Each Stage of PBL Model					Average Score for Each TCOF Category
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	
A (Strategy)	2,73	2,33	0,00	0,00	0,00	2,67 (High)
B (Response)	2,67	3,00	2,66	0,00	0,00	2,86 (High)
C (Activity)	0,00	0,00	2,66	2,67	2,33	2,76 (High)
D (Model)	3,00	3,00	3,00	0,00	0,00	3,00 (High)
Average Score of Each PBL Stage	2,76 (High)	2,83 (High)	2,93 (High)	2,50 (High)	2,33 (Medium)	2,82 (High)

Based on the results of the analysis in Table 1, it can be seen that the learning activities using the PBL model designed in the learning design are in accordance with the TCOF aspects because each activity in the PBL model has represented every aspect of TCOF. Learning with the PBL model can increase students' imagination in determining the pH route of natural indicators where students can use their imagination to understand how indicators can be a tool to detect the acid or alkaline nature of a substance or the pH of the substance based on the color change table on the artificial indicators presented. on LKPD. With the help of imagination, students can solve problems in LKPD and design experiments to determine the pH route of natural indicators made from leaves.

Experimental design is the determination of tools, materials, and methods carried out independently by each student. At the time of self-study, students were very enthusiastic to learn about the procedure for making natural indicators and how to determine the pH trajectory of the natural indicators that had been made. Some students also watched how it was made through the Youtube platform. Students also study relevant journals and then discuss with researchers about points that are not understood. Based on these activities, question item number 3 on TCOF obtained a score of 2.33. The assessment score on the TCOF question item number 8 has a maximum score of 3. Based on the results of observations during the independent learning process, the researcher also asks students to record important points found during the independent learning process. By noting important points during learning, it can be used as material for discussion with group friends at the next stage of learning, namely discussion.

The discussion activity aims for students to discuss problem solving plans and determine procedures for making natural indicators that have been studied individually at the previous learning stage with their respective groups.

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Discussion activities guided by researchers made students exchange opinions and thoughts with group members. Based on problem solving procedures and ideas for making natural indicators that have been discussed by each member of the research group, the researcher guides students to determine problem solving and establish procedures to be carried out in the experiment of making natural indicators in accordance with the relevant chemical theory. The results of student discussions are then presented through power points at the next PBL stage, namely developing and presenting their work. The TCOF score at the stage of developing and presenting the work has a lower score than the previous stage. This is because the teacher is still not motivating students to compile experimental reports in other creative ways such as concept maps. According to Alga (in Sartono et al, 2016) mind mapping can improve brain work, help students to store the material they have learned into Long Term Memory (LTM), and stimulate creativity and memory making it easier for students to access stored memory. In addition, mind mapping can also help students to optimize their abilities. The use of colors, images, and keywords as concepts and the interrelationships between concepts will be a trigger for students to remember the concepts in the learning material. Based on some of the uses of this mind mapping, researchers as teachers should be able to encourage students to make power points and reports that are equipped with mind mapping. At the end of the lesson, students are asked to summarize the lesson. Based on the results of TCOF observations, researchers are considered to be still lacking in encouraging students to make learning summaries in a creative form such as in a story, comic, drama or game. So that students can only summarize the lesson in the form of important points accompanied by pictures. Making a summary of learning in the form of a comic can be a creative process that involves imagination and reflection of structured thinking (Silva, Santos, & Bispo, 2016). The results of the learning summary in the form of comics are considered to be able to improve students' reading abilities, because visual literacy skills can help students understand important concepts in learning and can develop students' literacy skills (McVicker, 2007).

### ***Student Creativity During Learning Using the PBL Model***

Data on the creativity of students in this study was obtained through observation of creativity during the learning process. The observed aspects are based on William's creativity indicators. The results of observations of student creativity are presented in Figure 3.

Based on the results of creativity observations, it was found that the creativity of students as a whole was categorized as very good, namely 83.75%. The percentage on the fluency indicator has a higher score than other indicators. To develop the creativity of students on fluency indicators, researchers designed learning activities in the PBL model that stimulated students to ask questions about a problem and material that was not understood and express their ideas or ideas about problem solving and making natural indicators smoothly. Fluency refers to the total number of ideas (responses) generated (Kanematsu & Barry, 2016). Based on the results of observations during the learning activities, the students were very enthusiastic in presenting the problems found in the LKPD.

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Students also express ideas in making natural indicators smoothly. These actions show that the creativity of students on fluency indicators can be developed through the PBL model.

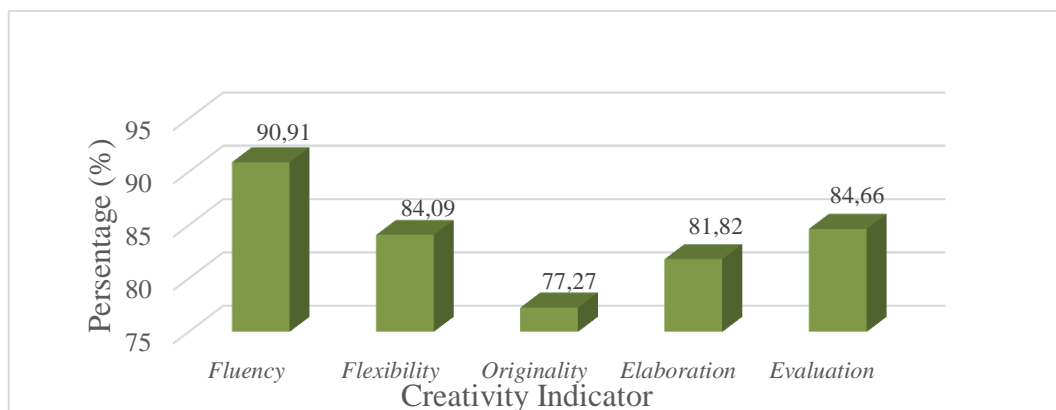


Figure 3. Student Creativity on Each William's Creativity Indicator

The creativity of students on the indicators of flexibility, elaboration, and evaluation also has a high category score. Flexibility indicators are developed through the stages of the PBL model where students can put forward various chemical theories that are relevant to the problem and provide various solutions to the problems found. The indicators of student elaboration are developed through class discussion activities where students explain the results of problem solving and the results of experiments carried out in detail.

The creativity of students on elaboration indicators is also developed through class discussion activities where students present the results of problem solving and the results of experiments in determining the pH route of natural indicators conducted through google meet in detail. Creativity in the elaboration indicator can be seen from the ability of students to describe a problem solving in more detail because of the knowledge gained through experimental activities (Wahyuni et al, 2019). In discussion activities, students also provide input and responses to the results of problem solving and experimental results presented by each group. Suggestions and inputs put forward by other groups are used as evaluation material for the results displayed by each group so that the creativity of students on evaluation indicators can be developed. The percentage is done by all group members where each part to be presented is divided based on group agreement. So that students can build their confidence in presenting the results of problem solving and the results of experiments carried out.

The creativity of students on the originality indicator has the lowest score among other creativity indicators. The aspect that is observed to assess the development of students' creativity on the originality indicator is the ability of students to express unique ideas that are different from existing ones. Observation results show that students can propose material ideas to make natural indicators, in this case choosing leaves that are different from other groups. According to Runco (Pang, 2015) the ability to provide an idea is an initial ability that must appear in the creative process. At the stage of organizing students to learn, each student

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presents his or her own ideas and then the ideas are discussed with members of their respective groups.

The idea of the material expressed by one group and another is different, but students still cannot express the process of making natural indicators that are completely new. Students still refer to journals and make modifications from the way of making natural indicators that exist in the journals referred to. The modifications made by the students were the modification of the type of solvent, the ratio of the solvent, and the variation of the immersion time. The creativity of students on the originality indicator is also assessed in the aspect of carrying out the experiment after first reading the theory that is relevant to the experiment being carried out. What is assessed in this aspect is the creativity of students in referring to various literatures. The observation results show that there are still students who only refer to 1 literature before conducting the experiment so that the method of making natural indicators is only a minor modification of the method in the literature but with a different main ingredient. Each type of leaf chosen by the students as the main ingredient in making natural indicators was yellow broccoli leaf, demung leaf, adam hawa leaf, and erpah leaf. These leaves were chosen by students because of their striking color. In addition, this leaf is quite easy to find around the student's residence so it is more practical in making. In making natural indicators from the selected leaves, all students used the extraction method, namely maceration. In the selection of solvents and the comparison of solvents used in the extraction process, students refer to 3 relevant journals.

Yellow broccoli leaves were extracted using two types of solvents for comparison. The solvents used were distilled water and ethanol with a ratio of 1:2. Demung leaves were extracted using bottled drinking water and ethanol as a solvent with a ratio between simplicia and solvent 1:1. The leaves of adam hawa were extracted using ethanol and ethanol+HCL as solvents with a ratio of simpisia and 1:1 solvent. Erpah leaves were extracted using aquadest and ethanol as a solvent in a ratio of 1:2. The time chosen by students in the maceration process is 24 hours. The indicator that has been made is then tested using a buffer solution with a pH of 1-14. The color changes that occur after the buffer solution with a pH of 1-14 is dripped with acid-base indicators from the leaves that have been made by each group of students are as follows.

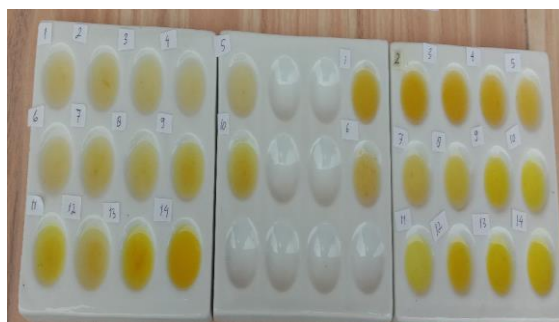


Figure 4. Color Change of Buffer Solution pH 1-14 After Dropping Yellow Broccoli Leaf Indicator

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Figure 5. Color Change of Buffer Solution pH 1-14 After Drops of Demung Leaf Indicator

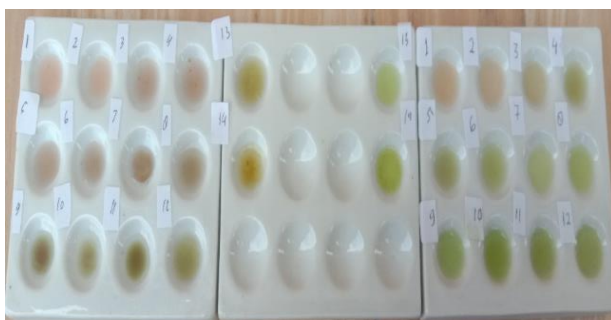


Figure 6. Color Change of Buffer Solution pH 1-14 After Drops of Adam Hawa Leaf Indicator



Figure 7. Color Change of Buffer Solution pH 1-14 After Dropping Erpah Leaf Indicator

Based on Figure 4-7 above, it can be seen that each indicator changes color when dropped with a buffer solution of pH 1-14. The results showed that students were able to make creative products in the form of natural acid-base indicators made from leaves. Each group has also been able to determine the pH trajectory of the natural indicators that have been made.

#### 4. Conclusion

Based on several research findings that have been presented, it can be concluded that the learning design with the PBL model is categorized as very feasible based

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on internal, external, and TCOF feasibility tests to develop student creativity and student creativity is categorized very well through learning using the PBL model.

### Acknowledgement

The researcher would like to thank as much as possible to all research participants who have been willing to take the time to carry out this research.

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How to cite this article:

Nafisah, Wahyu, W., & Sopandi, W. (2022). Feasibility Analysis of PBL Model to Build Student Creativity in Determining pH Route of Natural Indicator. *Journal of Educational Sciences*, 6(4), 590-602.

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