Improving the Students’ Comprehension on Acid Natural Indicator through Discovery Learning

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Article Info

Abstract
Teaching industrial chemical for students of vocational school in Indonesia is quite challenging due to the bulk materials in limited time. For Grade 10, the students should master the single and mixture substances into solutions. It means that they have to understand how to identify the acid and alkaline. In the laboratory, it is easy to recognize the acidity of a substance using litmus paper, pH meter or universal indicator. However, it would be tough if the students have to use natural indicator. By applying the classroom action research among students on grade 10 in one of vocational school in Yogyakarta, Indonesia, the current study attempts to increase the students’ competence in comprehending the use of natural indicator to measure the acidity. The discovery learning was chosen.

Introduction

Chemistry learning materials cover single and mixture substances. The single substance discusses elements with symbols, structures, and compounds. At the same time, the mixture substance refers to homogeneous and heterogeneous mixtures. A solution is also often defined as a liquid mixture. In other words, a mixture is commonly called a solution consisting of two or more kinds of substances mixed with various composition ratios but still has properties like the original components of its constituents.

In Chemical Vocational School, the solutions learning materials are grouped based on their ability to conduct electricity (electrolytes and non-electrolyte), and acidity (acid and alkaline) (Saidah & Purba, 2014). In understanding the acid and alkaline solutions, the students were mostly introduced by the of Svante Arrhenius (Fessenden & Fessenden, 1982). Acid is a substance that, when dissolved in water will be able to release H+ ions it has. In other words, the carrier of acidity in solution is the H+ ion. Arrhenius then formulated an acid solution as HxZ, and when dissolved in water, it ionized as follows:

\[ H_xZ_{(aq)} \rightarrow xH^+_{(aq)} + Z^- \]

An acid material has sour taste. When it is dissolved in water, it will produce H+ ions because it can release H+ ions. Furthermore, the acidic solution is an electrolyte solution. If measured with a pH meter, an acid solution has a pH below 7, so it will turn blue litmus paper red. Besides that, acid solutions are also corrosive. Bases are compounds that, when dissolved in water, will produce hydroxide ions (OH-). The carrier of fundamental nature is the OH- ion.
For recognizing a material carries acid solution, an indicator is needed. The indicator is a tool that can show a striking colour change/contrast if it is in an acid solution or an alkaline solution. An indicator is a tool that can indicate an indication that a solution has acidic or basic properties (Fessenden & Fessenden, 1982). Indicators consist of various kinds such as Single Indicator, Natural Indicators, pH meter, and Universal indicator.

A single indicator that can show a solution is acidic or basic is litmus paper. There are two types of litmus paper: red and blue litmus papers. Red litmus paper will turn blue when dipped in an alkaline solution. On the other hand, blue litmus paper will turn red when immersed in an acidic solution. Chemical indicators are phenolphthalein, methyl orange, bromthymol blue, and methyl purple. If we drip an acid or base solution with an indicator solution, we will get a change in the colour of the solution. The indicator changes colour with changes in pH. When the indicator changes colour, the pH limits are called the colour change path or pH range.

The Natural ingredient indicators are from plants as acid-base indicators. The definition of indicators is dyed that can show different colours in an acidic solution and an alkaline solution. To be used as indicators, these materials must be made in the form of a solution by extracting them. Then the natural indicator solution is dropped into an acid or alkaline solution.

All those materials should be learned for one year with three-course credits per meeting. It means that the students only meet the teacher once one week. For some materials that experiments can support, the students can easily understand the materials. Unfortunately, abstract materials which require deep understanding need more effort. One way to deliver massive materials in a minimal time is by adjusting the lesson plan design.

Each learning objective is set in one or two meetings in every lesson plan. It aims to reach the targeted competencies which the students should acquire after learning. Consequently, time management has become an important point. In this case, the teacher should be creative in providing and creating appropriate learning media which can facilitate the students in reaching the learning outcomes.

The learning media should be designed attractively, enabling the students' motivation to learn. When the students have gained their motivation in learning, they tend to feel happy in the process of learning. Furthermore, internal motivation directs the students to own their autonomous learning (Ryan & Deci, 2017). Thus, having a happy mood greatly supports the success of learning objectives.

The students’ problem in understanding the emulsion characteristics using the concept of acids and bases using natural indicators were also faced by students in Grade 10 in one of vocational school in Industrial Chemistry in Yogyakarta. It is because of the limited time for the students to explore further information and literacy. The chemistry subject is allocated in three learning credits which equals to around 120 minutes. During the two hours, of course, it is challenging to students exploring the materials and reaching the minimum requirement of the competence optimally. Therefore, it can be identified that the students were lack of understanding of natural indicators specifications and materials, the concept of acids and bases, and time.

The current study explores the natural indicators learning media used for analyzing the emulsion characteristics. Through the natural indicators, the students were expected to understand the concept of acids and bases. Commonly, for understanding and identifying the concepts of acids, bases and emulsion, some indicators used such as litmus paper, universal indicators, and pH meters. Those tools frequently can be obtained in the laboratory. Alternatively, calculating the substance pH concentration with particular formulas so that the students enable determine whether a substance is acidic or basic. Unfortunately, the students still faced difficulty in analyzing the properties of emulsion and exploring the concept of acids and bases using natural indicators.
In using the natural indicator, the students must take a series of steps to determine whether natural products such as leaf, flower or fruit can be used as an indicator. The students have not fully understood on how to determine substance criteria used for an indicator and how to use the indicator for determining whether a substance belongs to an acid or base substance. The degree of students’ difficulty was reflected in test results that have not exceeded the predetermined the Minimum Passing Grade.

The appropriate learning model which enables to support the achievement of learning objectives is highly required. The learning media should be designed to attract more students’ attention, provide various methods and activities, not merely listening to the teacher such as observing, demonstrating and doing. Thus, it is required a learning method which can invite the students’ curiosity and autonomy.

The use of discovery learning models is believed to arouse students’ enthusiasm for understanding in the learning process. Through the discovery learning, the students are invited to search and construct the knowledge by themselves (Ariyana et al., 2018; Bruner, 1961; Lefudin, 2017). The primary goal of the discovery learning is that teachers should provide opportunities for students to become problem solvers related to what students are learning. The discovery learning model offers two stages namely preparation and implementation (Lefudin, 2017). The former stage covers 1) the learning objectives determination, 2) student characteristics recognition such as the students’ initial abilities, interests, and learning styles, 3) subject matter selection, and topics determination. The latter procedures include the provision of stimuli (stimulus), problems identification, data collection (data collection and data processing), verification (verification) and concluding (generalization). In the present study, the discovery learning syntax was used to help the students in constructing their knowledge on identifying the nature of the solution whose acidity is not known using natural indicators.

Method

The classroom action research was applied in the current study. Each cycle consists of four stages namely planning, implementing actions, the impact of Implementation (observing and analyzing), and reflection which were used to find out the improvement of the students’ learning performance (Kemmis & Mc. Taggart, 1988).

Three cycles with two meeting each were designed on the present study. Cycle I was carried out to identify the properties of solutions based on the concept of acids and bases, using existing natural ingredients. Students explore relevant information and conduct discussions and presentations. The students were facilitated to understand the meaning of acids and bases. Cycle II was to analyze the properties of solutions based on the concept of acids and bases using substance x as a tester of natural indicators. The students were divided into groups of four members in each group. Each group was given a worksheet for discussion, elaboration, exploration, and presentations on making natural indicators and their use. The last meeting was more individual, with the same worksheet, and an evaluation was carried out. On the Cycle III, the students work in groups with a practicum worksheet. The assessment was done by giving written test questions at the end of the lesson.

In Indonesia, the learning process is indicated successful if the minimum passing grade more than 70% (Sudjana, 2006). However, the school has an authority to set the minimum passing grade applied in their school. The vocational school where the study was conducted set the minimum passing grade on 75%.
Results and Discussion

Before conducting the first cycle, the initial observations were carried out as a pre-cycle action to know the extent to which concept mastery was measured as a result of student learning through data analysis and the achievements of Grade X KI B students. In this pre-cycle activity, the learning process applied a discovery model. The teacher facilitated the students in constructing their knowledge on solution properties based on the acids and bases concepts using the natural indicator. The students began to observe and discussion on the learning materials presented by the teacher. These activities was followed by an assessment. Unfortunately, the result did not meet the expected results. Among the 32 students, only 12 (38%) passed the Minimum Passing Grade. Students tended to be inactive and monotonous in asking questions. Because the test scores do not meet the specified criteria, this problem is used to determine actions in the next lesson. Based on the data obtained from the pre-cycle activities, the process on the first cycle of the study was carried out.

Cycle One

Planning

Cycle I process was conducted in two meetings. The teacher explained the initial material about the procedure for carrying out the analysis in the context of providing stimulation. Motivation was given so that students could identify problems. The teacher facilitated the students to explore information then collect and process the data obtained. Through discussions and presentations, students enabled to express their opinions to get problem solutions.

Stimulus was given to students by providing a variety of flowers and leaves from surround. Providing various types of flowers and leaves has provoked students' curiosity in searching the acidity properties of those items. Then, the teacher let the students identify the solution X by mixing kinds of flowers and leaves.

Observation

At the second meeting, students were divided into eight groups. Group 1-3 run the testing 1. Group 4-6 did the testing 2. The rest group conducted the testing 3. Before doing the testing, all groups elaborated information from available guided books and the internet. It was followed by conducting group discussions and doing presentations.

In the testing activity 1, three groups boiled each flower, then mixed it with vinegar representing acid, NaOH representing base and substance x. It turned out that the colour produced did not show a significant difference. It has been noted that flowers that can be called indicators give a striking colour difference when reacted with acids and bases. Identification of substance x still cannot be accounted for because after comparison, the test with red litmus paper and blue litmus paper does not match the reference. Therefore, the first activity did not answer the question of the actual nature of substance x.

In the testing activity 2, three groups blended the flowers with water as a solvent. The mixtures were, then, divided into three. Each was mixed with different substance, namely vinegar representing acid, NaOH representing a base and substance x being the substance to be investigated for its properties. Then, testing the substance x was with red litmus paper and blue litmus paper as the easiest but most accurate comparison. The results showed almost the same colour for the three samples observed so it was not possible to determine the nature of substance x.
In the testing activity 3, two groups mixed each flower with alcohol. The mixture was divided into three samples. One was mixed with vinegar to represent an acidic solution. NaOH was to represent a base emulsion. The last was the substance X to be investigated for its properties. The substance X was tested with red or blue litmus paper for a more convincing test. Several flowers showed striking colour differences when they were mixed with vinegar and NaOH respectively. This means that the flowers could be used as an indicator. When the sample is mixed with substance X, it turns out that there is the same colour as the mixture sample with vinegar. It could be concluded that the substance X was like vinegar which belonged to acid. Next, the substance X was tested with red litmus paper and blue litmus paper. It turned out that the red litmus paper did not change colour and the blue litmus paper turned red. This means that the substance X was acidic.

Based on observations, 75% of students did exploration and practice with a variety of flowers and leaves. The self-assessment data showed that 95% of the students did practicum, 85% said that the learning material was easy to understand, and 85% of students said learning was exciting. Furthermore, 20 of 35 students or 57% of the students gained evaluation score above the Minimum Passing Grade.

However, the students had not found the proper working procedure for processing various flowers or leaves yet. Consequently, the students have not been able to determine the criteria for flowers or leaves as natural indicators. The final impact was that students had not been able to decide on the nature of substance X because the solution obtained was not by the evidence of testing substance X with red litmus paper or blue litmus paper.

**Reflection**

In the second cycle of learning, the stimulus provided by the teacher with various practicum materials was able to attract students’ interest in identifying problems by testing substance X. Although during the process, data collected from each group was still different. Of course, this would significantly affect the subsequent data processing so that the conclusions drawn were not necessarily required. Of the eight groups, six groups did not find the right way to test the practicum materials. Meanwhile, two last groups succeeded to collect and process the data.

**Cycle Action Two**

Based on the action results in cycle 1, it has not shown satisfactory results. At the first meeting of cycle 2, the researcher tried to give the students a stimulus to process the various flowers and leaves to identify the nature of the solution of substance X. The students continued to work in groups and find ways to process the various flowers and leaves as natural indicators. The existence of several types of flowers and leaves were expected to be suitable to provoke creativity and skills from students in working in groups. Each group conducted discussions and trials with various tests on the various flowers and the use of supporting solutions in the laboratory.

In the implementation stage, the grouping and steps of doing the work group practicums were still similar to the Cycle I. The different laid on the kinds of flowers and leaves used.
The graph shows that the students’ percentage in doing the discovery learning phases. Overall, the students participated positively which could be seen from the maximum percentages on presentation, drawing hypothesis, testing, analyzing and conclusion. However, based on observations, 75% of students did exploration through group discussion with a variety of flowers and leaves. From the self-assessment, it could be gained information that 95% of children did practicum.

Unfortunately, from the evaluation data, there was still 20 out of 35 students or 57%, scored above the Minimum Passing Grade. Students have not found the proper working procedure for processing various flowers or leaves, so they have not been able to determine the criteria for flowers or leaves that can be used as natural indicators. The final impact is that students have not been able to decide on the nature of substance x because the solution obtained is not by the evidence of testing substance x with red litmus paper or blue litmus paper. Based on discussions between researchers and collaborators, one of the two groups treated flowers by mashing and diluting them with alcohol to briefly present the results of the work done as a confirmation of learning that day.

The following data shows the comparative students’ scores gained after the Cycle 1 and II.
The graph shows that some students enabled to improved their performance in involving the learning activities on understanding the natural indicators. In the second cycle of learning, the stimulus provided by the teacher with various practicum materials was able to attract students' interest in identifying problems, namely testing substance x. Although in the process, collecting data from each group is still different. There were three kinds of treatment for the practicum material; of course, this would significantly affect the subsequent data processing so that the conclusions drawn were not necessarily by the theory put forward by the existing literature. Of the eight groups, six groups have not found the right way to treat practicum materials, so they have not found a match between theory and practice. Meanwhile, two groups have carried out data collection and data processing correctly to conclude from the results of the practicum by the literature. After going through discussions and presentations from the two groups, it was agreed to carry out a practicum on natural indicators according to the work steps of the two groups.

**Cycle Action Three**

**Planning**

In this cycle, students still work in groups, with the stimulus from the conclusion of the learning outcomes in cycle two. Students work in groups, making work methods to test whether various kinds of flowers can be used as natural indicators or not. Based on the results of previous work, students are expected to be calmer in working on the task of making the work steps of identifying natural indicators because they have more or less understood the description of what to do from the previous meeting. This can be seen in the results of the pre-test that has been done has experienced a significant increase, exceeding the post-test results conducted in cycle II. The discussion results on making these work steps are presented per group. Most of the presentations made by students have been focused on the results of the work on identifying natural indicators of various flowers and leaves.

**Implementation**

At the first meeting of cycle III, students practice the work plans that have been made. From the Observation of the learning process, students work in groups. Of the eight groups, they all did the same way of working; namely, the flowers were mashed and dissolved in alcohol. Three samples were taken from the mixture formed, with each sample mixed with vinegar, in this case representing the acid group, NaOH representing the base group, and substance x, whose properties are not yet known. The cheerful atmosphere can be seen from the expressions on the students' faces when they observe various colours and changes in colour from the mixture of flowers and alcohol with vinegar, NaOH and substance x. The existence of interesting colour changes increases students' curiosity to test each flower. With the direction of the researcher, students group the observed colours of vinegar, NaOH and substance x, as in the appendix.

From the discussions and presentations from each group, almost the same results were obtained; the difference was only in the type of interest data so that all groups agreed upon the conclusions obtained. The model of the grouping carried out by students is as follows:
Table 1. Natural Indicators

<table>
<thead>
<tr>
<th>No.</th>
<th>Flower/leaf</th>
<th>Vinegar</th>
<th>NaOH</th>
<th>Substance X</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Red rose</td>
<td>dark</td>
<td>dark</td>
<td>red</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Hibiscus</td>
<td>red</td>
<td>green</td>
<td>red</td>
</tr>
<tr>
<td>3.</td>
<td>Pandan Leaf</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>4.</td>
<td>Kenikir</td>
<td>yellow</td>
<td>yellow</td>
<td>yellow</td>
</tr>
</tbody>
</table>

Observation

From the results of observations and discussions, students can finally determine the nature of the solution of substance x. This is proven by the test of substance x with red litmus and blue litmus, giving the exact indication of the nature of the solution substance x by the literature. In the learning process, 95% of students were observed working in their groups, and 95% of students were able to receive learning materials.

The evaluation turned out that 30 out of 35 students, or 85.71%, exceeded the minimum completeness criteria.

Figure 4. Weekly Assessment on Cycle III

Through discussions with collaborators, the factors that support student success in terms of obtaining test results are repeated learning, students find their understanding of the nature of the solution from digging up information on the internet and sourcebooks as well as discussions carried out, then practised by undergoing a series of activities. The work steps they make themselves, and students can directly observe the theory obtained from the source and

Figure 4. Weekly Assessment on Cycle III
direct Observation of the practice carried out are authentic evidence embedded in students’ memory without having to memorize it.

From the description above and from the observations of the learning process to analyze the properties of solutions based on the concept of acid-base in class X KI B, the learning process is the process of obtaining results to find answers to existing problems. The process that is passed to understand oneself from the understandings obtained in theory with factual evidence obtained from a series of performances carried out will lead students' opinions to find their knowledge or experience of a theory or concept being studied so that with their opinion students can express the notions or interpretations of a theory or concept in the style of each student but by the literature studied. This process of self-discovery is what experts call Discovery Learning. From providing stimulus by the teacher, encouraging students' curiosity to identify problems. Extracting information from various sources will support data collection, proven by a series of performance processes. In the end, students can conclude the answers to the problems faced.

Reflection

Giving stimulus by the teacher is provided at the beginning of the lesson by presenting various kinds of acid and alkaline solutions and indicators that can be used to identify the acid and base solutions. Until finally arrived at natural indicators. Students are exposed to various kinds of flowers and leaves, how to determine which flowers and leaves can be used as indicators, and how to use them to identify solutions. From the questions that arise, students will be able to identify existing problems, namely identifying flowers/leaves as indicators and then using them to identify the properties of solutions whose properties are not yet known.

Through exploration by digging up information from sourcebooks available in libraries and student handbooks and through the internet, students collect data regarding the meaning of acid, understanding of bases, understanding of natural indicators and how to process various flowers/leaves to determine flowers/leaves, which can be used as indicators and their characteristics. This process was observed in cycle I, cycle II and cycle III. With the portion in cycle III the most time. It happens because students are still not open to the materials around them but are still much interested in searching for sources on the internet. It is where the role of the teacher in managing the class is needed, as a supervisor always reminds of the limited time available, as well as on setting the time for discussions and presentations made by students.

Presentations and practicums carried out by students to prove the theories or concepts that have been studied are carried out in each cycle. In the first cycle, the proof is not by the theories or concepts studied, so students are still confused about the meaning of identifying the nature of acid-base solutions using natural indicators, constrained by the treatment of flowers used as samples, which is still not correct. In cycle II, only two groups of students found the proper steps to treat various flowers. From some of these flower tests, students were able to determine which flowers could be used as indicators and could be used to test the properties of the solution on substance x. Students found definite evidence from observations, the colours shown on each flower in a solution of vinegar, NaOH and substance x. After the practicum was repeated three times for each flower/leaf to get more robust results, students finally understood that from these colours, it could be determined whether a flower/leaf can be used as an indicator or not, according to the theory in the literature. Thus, students can conclude which flowers/leaves can be used as natural indicators. To test the results of that conclusion, the natural indicator that has been determined earlier is used as a test of the nature of the solution of substance x. In this case, substance x is provided by the teacher. The truth of this test will be proven by testing using red litmus paper and blue litmus paper, where the solution is acidic.
when dipped in red litmus paper, and the litmus paper does not change colour, if it is dipped in blue litmus paper, then the litmus paper turns red, which indicates the nature of the solution is acidic, according to the literature sulfuric acid is acidic.

Based on the discussions with collaborators, there were significant results from cycle I, cycle II and cycle III.

Figure 5. Assessment Score Comparison among Cycles

Based on these data from cycle III, the test results have exceeded the agreed limit, namely, students who get scores above the minimum completeness criteria of more than 70%. In contrast, in this study, 30 of 35 students or 85.71% of students have, been able to exceed the minimum completeness criteria set.

**Conclusion**

Practical learning based on natural indicators using the Discovery Learning model makes students experience a significant increase in finding their way of understanding the theory or concept of the nature of an acid or base solution. Learning by using the Discovery Learning model makes students able to: (1) Identify the nature of the solution based on its acidity, which is divided into acidic solutions and basic solutions. (2) Students can also test the nature of acidic or basic solutions, which can be done using natural indicators that are widely available in the surrounding environment. The evaluation results carried out from the first cycle to the third cycle showed an increase in learning outcomes. A total of 35 students, only 19 students who managed to get a value beyond the Minimum Passing Grade or 51% in the first cycle, increased to 30 students who succeeded in exceeding the Minimum Passing Grade limit or 86% in the third cycle by using the discovery learning model, can improve student learning outcomes in analyzing properties of solutions using the concept of acids and bases through the use of natural indicators. By practicing in groups, the students experimented on how to using natural materials to indicate acid and present the results. Thus, the ability of students to analyze and evaluate the properties of solutions using the concept of acid-base with natural indicators is significantly improved.
References


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