ISSN 2964-4291
https://proceeding.unnes.ac.id/index.php/iset

Chemistry Practicum Learning During the Covid-19 Pandemic: Determining the pH Scale of Acid-Base Natural Indicators with Semi-Quantitative Analysis Using Spectrum Color Measure Software

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Abstract. Learning in the laboratory or lab course is very crucial and inseparable in studying chemistry. Since the covid-19 pandemic, student's activities wet-laboratories were almost has eliminated. Several methods have been implementing to accomodating laboratory experiences, such as learning videos, virtual laboratories, and practicals using household/kitchen equipment (lab at home). This study aims to analyze the creative thinking skills of first-year chemistry students after implementing a do lab at home lab course. The learning activities embrace students to done, not only qualitative but also quantitative (semi-quantitative) analysis. The research was conducted in 2 classes of first-year chemistry students and focused on the aside-alkalimetry titration material. This study uses a mixed-method with explanatory sequential mixed methods design. The results of data analysis were showed an improvement in student's conceptual understanding, although it was not statistically significant. Even so, the level of student's creative thinking was increasing a lot. It founds that students could provide differents equipment and materials in the same problem, even beyond the goal learning expectation. Some students have high enthusiasm for the project design process. In addition, basic scientific skills, such as observing, formulating hypotheses, collecting data, and data analyze improved a lot too because they do a science lab.

Keywords: basic chemistry practicum; home science; acid-base pH scale; color spectrum.

How to Cite: Dewi, S. H., Haryani, S., Sulistyaningsih, T. (2021). Chemistry Practicum Learning During the Covid-19 Pandemic: Determining the pH Scale of Acid-Base Natural Indicators with Semi-Quantitative Analysis Using Spectrum Color Measure Software. *ISET: International Conference on Science, Education and Technology, 7*(1), 551-557.

INTRODUCTION

The Covid-19 pandemic has hit the world since 2019, not only affecting health but also in almost all aspects of life, including education. All learning and teaching activities are carried out by distance learning, or better known as online learning. Online learning for theoretical materials may still be carried out optimally with all its weaknesses and advantages. Practical learning that should be done in a wet laboratory, especially in the fields of science and engineering, is also conducted online.

Since the Covid-19 pandemic, there has been a lot of research and innovation related to chemistry practicum activities. One of them is to use materials and tools around the house of each student or student. Some have turned their kitchen into a lab (kitchen lab), used demonstration videos, and used virtual labs. Although the results are not as ideal as practicum in a wet lab, with these activities or media, students (students) are still trained to work like scientists who work in the lab.

There are some skills that cannot be trained when conducting online practicums, especially aspects of skills in the use of laboratory equipment and the use of chemical substances. The student is unlikely to work with concentrated sulfuric acid at home, unless he has a chemistry lab in his home. Some affordable glassware may be purchased by students independently, but of course it cannot be as complete as in the campus laboratory.

Practicum Chemistry 1 is a basic and mandatory course for first year students of the Chemistry Department, State University of Semarang. The practicum is a new course and was first applied in the even semester of 2020/2021. The material in this course is a combination of basic chemistry and basic analytical chemistry. Facing this opposition, various methods were used so that the practicum could run optimally. One of the methods applied is to conduct experiments using tools and materials that are around the house, hereinafter referred to as a do lab at home practice.

The main purpose of the do lab at home practicum is to provide hands-on practical experience but it is still safe to do it at home so as to arouse the scientific side of students. Activities in this study discuss on acid-base materials including identification of acid-base solutions, buffer solutions, and acid-base titrations. Practical activities are not only limited to qualitative experiments but are also directed to carry out quantitative analysis. Another objective of this practicum is to analysing the level of students' creative thinking skills in solving problems.

LITERATURE REVIEW

Practical activity is one form of learning that has been applied for a long time. Like other learning strategies, practicum activities also refer to several learning theories, such as Bruner's learning theory or discovery learning. There are four main points related to Bruner's learning theory (Baş & Beyhan, 2010; Hung et al., 2012). First, the individual only learns and develops his mind when he uses his mind. Second, by carrying out cognitive processes in the discovery process, students will get a sensation and intellectual satisfaction which is an intrinsic reward. Third, the only way that one can learn the techniques of discovery is to have the opportunity to make discoveries. Fourth, by making discoveries, it will strengthen memory retention. These four things correspond to the cognitive processes needed in learning using the scientific method.

Learning in the laboratory or better known as practicum activities, is one type of learning method that is mandatory in universities, especially in the fields of science and engineering. Experts believe that practical activities are very important in learning (Reynders, Suh, Cole, & Sansom, 2019). The practicum method was first developed at the end of the 19th century with the aim of improving the skills of prospective technicians and researchers. Practicum activities continue to be developed to date with various studies related to the benefits of practicum learning (Clapson et al., 2020; Clark et al., 2016; Sri Haryani et al., 2019).

The results show several benefits of practicum, which can be organized into general categories for researching key concepts in science, motivating and generating interest in science, developing laboratory skills, gaining an understanding of the practices used by researchers, working in teams, and learning time management (Bretz, 2019). While there is much thought about the usefulness of laboratory learning for student learning in chemistry, the general sentiment remains that the laboratory is expected to be a place for students to support and interpret chemistry as an experimental science and as opposed to chemistry (Galloway et al., 2016).

Practical activities, if carried out in the right way, are one of the laboratory activities that play a very important role in supporting the success of the teaching and learning process of science, including chemistry. Practical activities make students: 1) able to learn science through direct observation of scientific phenomena and processes, 2) can practice scientific thinking skills, can find and develop scientific attitudes, 3) and can find and solve various new problems through methods scientific studies (Armstrong et al., 2019; Clark et al., 2016; Deckert et al., 1998; S. Haryani et al., 2017; Sri Haryani et al., 2019).

These goals or benefits seem to be theoretical in nature and although there has been a lot of research on what drives conceptual change in the laboratory, there are still many factors that hinder learning in the laboratory (Haryani et al., 2019). The two most salient factors are the following: (1) most laboratory experiments use "cookbook" procedures that students can follow and run successfully without thinking about the larger purpose of the investigation, and (2) laboratory learning assessments are largely focused on content knowledge and the ability to perform specific techniques while ignoring the student's understanding of the scientist's practice and the aims of laboratory investigations (Bortnik et al., 2017; Breslin, 2012; Holme et al., 2020; Lanigan, 2008; Lunsford & Slattery, 2006; Lyle & Robinson, 2001).

The form of practicum consists of practicum that is training, practicum that is giving experience, and practicum that is investigative or investigative. Practical form of practice aims to develop basic skills, such as using tools, measuring, observing or observing (Leopold & Smith, 2019). Practical form of experience aims to improve understanding of the material. Implementation practicum in the form of experience can be in the form of an induction or verification model. Practicum that aims to build principles, generalizations, or theories from the relationship of facts is an induction model. On the other hand, practicums that aim to prove the truth of a principle or theory through facts include a verification model. Furthermore , The investigative form of practicum aims to develop problem-solving skills. In this practicum, students are required to act as a scientist (Manchanayakage, 2013; Marcelino et al., 2019; Marteel-Parrish & Lipchock, 2017; Merino-

Rubilar et al., 2014).

At the beginning of its development, perhaps even now, learning in the laboratory in general is still guided by methods and procedures such as recipe books. Students carry out practicum activities with fully prepared themes, materials, and procedures. The initial goal which requires students to improve scientific skills turns into “to get grades” or “as a condition for the next course” so that the essence of the practicum activities is less meaningful (Clark et al., 2016; Santos Santos et al., 2010). Especially for chemistry education students, sometimes practicum activities are only considered as compulsory subjects that must be taken in order to graduate. Most assume that practical activities, especially in higher-level courses, will not be taught in secondary schools.

METHOD

This study uses a mixed method (mix method) with a convergent mix method model, meaning that quantitative data and qualitative data are taken almost simultaneously to provide a comprehensive analysis (Creswell & Creswell, 2018). The research subjects were 2 classes majoring in chemistry, more precisely 1 class with a pure chemistry study program and 1 class with a chemistry education study program.

Practical activities are carried out in 3 weeks, divided into 2 phases (phases 1 and 2). Each class is divided into 3 groups. In phase 1, each group designs an experiment with a different topic. Each group presents their experimental results in phase 1 so that a complete experimental design will be obtained that can be applied to phase 2. The main challenge of this practicum is how to do quantitative analysis on acid-base titrations using tools and materials at home. It is hoped that this activity will bring up creative ideas from students. The instruments used in this study were test questions, project assessment sheets (to assess practicum videos and assessment reports), and self-assessment questionnaires.

RESULTS AND DISCUSSION

The practicum activities applied were inspired by research conducted by Andrews et al (2020) with a few modifications. This research focuses on Acid-Alkalimetric Titration, with the main project being acid-base titration. The project is divided into 3 sub-projects with 2 implementation phases. The materials for each sub-project are different, consisting of materials for making buffer solutions, making natural acid-base indicators, and acid-base titrations.

The practicum activities are divided into 2 phases, namely phase 1 and 2. Phase 1 consists of separate activities, with 3 groups. Group 1 is tasked with designing and practicing accurately how to make a buffer solution from vinegar and baking soda. Group 2 is tasked with designing ways to measure and analyze the color spectrum. Group 3 is in charge of designing procedures for determining and making acid-base indicator solutions from natural materials that exist in their living environment. Phase 2, is the implementation of the project by combining all sub-projects into a single unit.

Group 1 sub-project, designed a way to prepare a solution of acid-base and baking soda with known concentrations. If done in the laboratory, it is very easy because there are analytical balances and other adequate measuring tools. The main challenge in this sub-project is how to measure solids and liquids in order to obtain a solution of a certain concentration. The possibility of participants using analytical balances like in a laboratory is very small or almost impossible. During the discussion process, various alternative solutions to these problems emerged. An interesting finding is the difference in concepts applied between group 1 chemistry class (grade A) and group 1 chemistry education class (grade B).

In class A, a method was chosen using the concept of solubility and saturated solution to determine the mass of baking soda. The solubility of baking soda is assumed to be 6.9 g/100 g of water at 0 and the density of water is assumed to be 1 g/mL. To make this solution, the students dissolved some baking soda in some ice water until it was exactly saturated with a concentration of ~0.82 M. This solution was used as the mother base solution. Making acetic acid solution, by utilizing data on levels and density of acetic acid. Data on the acid content of various brands of vinegar was obtained based on the results of previous years' practicum and the density of vinegar was assumed to be 1.05 g/mL. Student calculations show the initial concentration of vinegar is 4.7 M. Based on these data, various buffer solutions can be made with a certain pH. Measurement of the volume of liquids using a syringe or cooking utensil that can be used as a means of measuring the volume of liquids. The weakness of the class A method is that there are various data that are not necessarily the actual data (the result of agreement) for example for the density of water and the density of vinegar.

The solution for sub-project 1 in class B applies the concept of physics to determine the mass of a solid (baking soda). Students were inspired by a youtube video on how to make a scale using a simple lever principle (youtube link:https://youtu.be/v9hpWU9g0jA). The principle is like a 2-arm scale using an iron ruler. The weights used are coins. The video also explains the principle of the calculation. This method is more thorough than the solution from class A. This shows that the search for information by students can be wider, even across fields. They also expressed more interest in trying new things. For the manufacture of vinegar solution, it is almost the same as class A because it is easier to get a measuring instrument for liquids in everyday life. Actually, to determine the mass of solids, you can also use a cake scale, but too many ingredients will be used. While in this practicum it is also emphasized to apply the principles of green chemistry related to the use of stoichiometric materials.

The Group 2 sub-project is looking for ways to measure the color spectrum of various solutions. If it is done in the laboratory, generally using a UV-Vis spectroscopy tool, but of course this cannot be done at home. To overcome these problems, students are directed to the basic concepts of colorimetry. Color measurement is done by applying component analysis Red:Blue:Green (RGB) using a software application. This is done by taking pictures of the solution to be analyzed.

There are also differences in the solutions used between classes A and B. In class A, RGB analysis is carried out using Photoshop or Corel-Draw applications, while in class B using the On Color Measure application. Both produce the same data, namely the RGB ratio, but not all students can run the Photoshop application because it is generally paid, while the On Color Measure application (Figure 1) can be downloaded for free. In addition, the Color Measure application can provide the name of the analyzed color. The results of RGB measurements can be seen in Figure X. This sub-project 2 implements technological developments, as the demands of 21st century learning.

Figure 1. On Color Measure app display

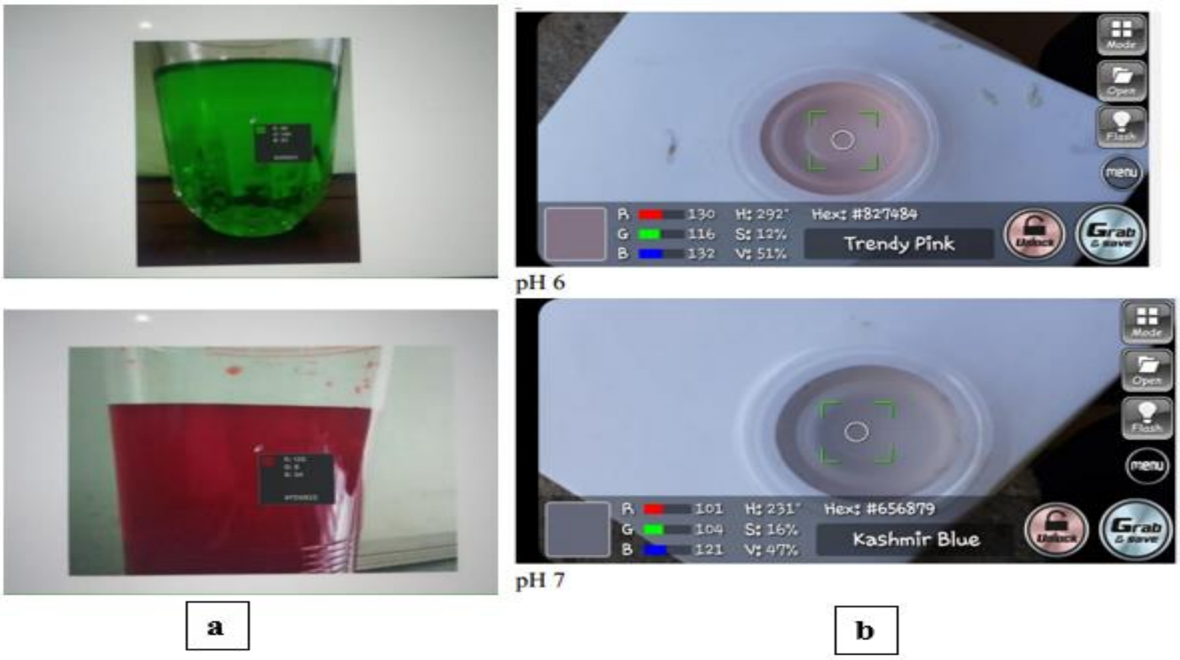

Figure 2. RGB analysis results with the application of a) Photoshop and b) On Color Measure

The Group 3 sub-project aims to design ways to identify natural materials that can be used as acid-base indicators and ways to manufacture acid-base indicators from these natural materials. Despite receiving the same instructions, there are still differences in results. In class A, each student in group 3 tried 1 natural ingredient that was thought to be an acid-base indicator in various solutions such as detergent solution, toothpaste solution, orange juice solution, and even coffee solution. Here, it can be seen that students do not understand the meaning of the concept of natural indicators of acid-base, moreover, some of the test solutions are dark in color, causing observational bias. In class B, understanding of project instructions was better, they decided to use vinegar solution as an acid solution, clean water as a neutral solution, and a baking soda solution as a base solution. Then each member looked for a different natural ingredient, extracted it, and then tested it in the three solutions. Based on these results, of course the method from class B is more in line with the demands of the project.

Phase 2 is the combined implementation of all the sub-projects, forming a single project design. This project aims to titrate a vinegar solution with a baking soda solution or vice versa. Each student prepares a buffer solution with various pH according to the instructions of sub-project 1, makes an acid-base indicator solution from natural materials according to the instructions of sub-project 3, and determines the RGB ratio of a buffer solution that has been given a natural acid-base indicator using the instructions of the sub-project. 2. From this activity, calibration curve data will be obtained, namely the RGB ratio of natural acid-base indicators at various pHs. This will be applied to the titration process, by comparing the color of the solution in the titration results and the color of the calibration curve.

Based on the results of the practicum, class A did not meet expectations, where the project was only carried out to determine the route of the acid-base indicator from natural materials. Each group member tried the analysis at a different pH, then the data were combined to create a calibration curve. This was done because of the limitations of project implementation and unclear instructions. At least every student has practiced directly and deserves to be appreciated considering the existing limitations. In addition, this activity also received a positive response even though it was carried out at home and using simple equipment.

The results of the project implementation in class B were better than those in class A, because they also carried out the acid-base titration process even though they used an injection or a dropper instead of a burette. One of the results of making a calibration curve, shown in Figure 3, is a graph between RGB values at various pHs. After that, a titration demonstration was carried out to compare the results of calculations and experiments. One of the indicators used is turmeric extract. A total of 20 mL of vinegar solution was added with baking soda solution. Based on the calculations, the equivalence point should be for adding 12 mL of baking soda solution (approximately pH 9), but it takes 14 mL to reach pH 9 based on the calibration curve. The difference in results is caused by several factors, for example the use of measuring instruments that are less precise, and the calibration curve is inaccurate. Measurement of the color spectrum with the RGB analysis method is strongly influenced by the image/photo taken. Differences in light intensity and image position will result in different RGB ratios. Therefore, this method is referred to as the semi-quantitative analysis method.

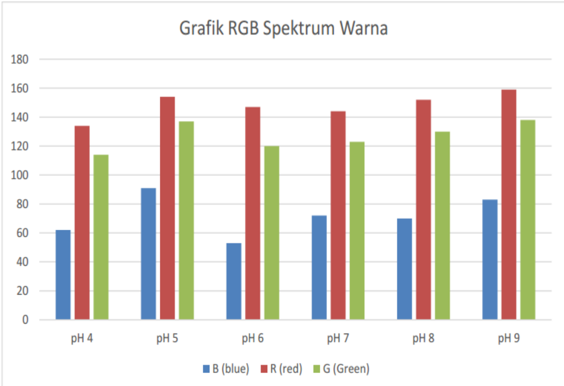

Figure 3. Example of a calibration curve using a turmeric indicator

The results of the pretest and posttest in this practicum showed an increase even though it was not significant. This is influenced because the questions used are descriptive questions and the processing time is quite loose. The test is carried out through the elena.unnes.ac.id platform, and supervision is not optimal because students can still open books. But at least there is an increase in understanding related to several concepts, for example understanding the concept of solubility. During the pretest and project implementation, there were still some students who did not understand the meaning of solubility and its application. There is even a misconception that dissolution is a chemical reaction process, whereas dissolution is a physical change.

The level of students' creative thinking also increases. This is evidenced by the emergence of several alternative solutions to the same problem. Some students have high enthusiasm for the project design process. In addition, basic scientific skills, such as observing, formulating hypotheses, collecting data, and analyzing data can also be trained because they conduct real (scientific) science experiments (not only analyzing practicum videos). Project implementation can also practice time management and teamwork.

CONCLUSION

Basic Chemistry Practicum in the form of do lab at home can be used as an alternative to carry out learning in the laboratory (practicum) in distance learning, especially during this covid-19 pandemic. The do-lab home practicum that is applied trains students to carry out both qualitative and quantitative analysis, although it is not entirely accurate. Home lab practicum can train students to conduct further investigations, as real scientists work. This research still needs to be developed further in order to produce a better activity design.

ACKNOWLEDGEMENTS

Sri Kadarwati, Ph.D and Dra. Sri Nurhayati as collaboration lecturer in data collection during the research.

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