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Research Article

Digitization of laboratory equipment using PhET simulation media in applied chemistry practicum

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ABSTRACT

Understanding the concepts of applied chemistry in the Graphic Engineering Study Program at the Creative Media State Polytechnic is very important to support their field of expertise in understanding more complex material. The Applied Chemistry course consists of various abstract concepts, including acids and bases. The use of computer programs such as PhET media is very important to explain the abstract material. The aim of this study was to describe the use of PhET Simulation, knowing the effectiveness of using PhET Simulation media in acid-base practicum, knowing the advantages and disadvantages of using PhET Simulation in acid-base practicum, and the purpose of this study was to see student learning outcomes after the application of PhET media in learning. The method used is a descriptive method that begins with the manufacture of media devices and student worksheets and performs a descriptive analysis of learning outcomes after the application of learning. The trial subjects in this study were first semester students who programmed the Applied Chemistry course. The research instrument is a learning outcomes test which finds 10 numbers of true and false questions and 5 numbers of essay questions. The results showed that the application of PhET media was effective in acid and base practicum. The average student learning outcomes are 65 ± SD 18 (good category). Based on student assessments after learning, it was found that students were very happy to learn by using PhET media.

Keywords: PhET; Chemistry; Laboratory; Applied Chemistry; Practicum

1. INTRODUCTION

In the current Industrial Revolution era, namely the Industrial Revolution 4.0 era, various problems arise, especially problems in the learning process in the field of education. As we know, during the COVID-19 pandemic, the Indonesian government issued a policy that the learning process was carried out online from their respective homes. With this policy, we as educators must be able to carry out various kinds of innovations for the learning process that will be carried out online, namely by utilizing the sophistication of existing technology with the aim that the material presented can be conveyed properly to the students we teach. One of the innovations that can be done in virtual learning is through Google Meet. Google meet is an application that can be downloaded from a gadget or laptop which is usually used as a place to study, discuss or meet online.(Maulani et al., 2021)

A laboratory is a container or place for a building or room with all kinds of equipment needed for scientific activities (Aminah et al., 2020). Animations and simulations have long been recognized as important in the teaching and learning of chemistry with increased access to technology in the classroom, interactive visualization tools have emerged as uniquely powerful for transforming chemistry education. Interactive simulations provide dynamic access to multiple representations, make the invisible visible, scaffold the inquiry process, and allow for multiple trials and rapid feedback cycles, while being engaging and fun for students and teachers. Interactive simulations are readily accessible online, which allows for flexible use (Moore et al., 2014). In the Applied Chemistry practicum course at the Creative Media State Polytechnic in this case the Applied Chemistry Practicum material about determining the pH of acid and alkaline products still uses manual practicum tools, so the error rate in terms of data collection is still large, so the final result of the practicum is still far away. than desired. Therefore, it is very necessary to create a digital practicum tool in order to streamline time and minimize the error rate in data collection, so that the final result is as desired (according to the reference).(Sudarmanto, 2013)

Based on the results of researchers' observations through teaching results at the Creative Media State Polytechnic, there are several problems in learning applied chemistry, namely students think that chemistry is difficult, lots of formulas, boring and scary, besides that students are lazy to ask questions and are less creative if they don't understand the material being taught. , resulting in low student learning outcomes. Learning outcomes are psychological behaviors that will be changed in the educational process. Learning outcomes are divided into three, namely: cognitive, affective and psychomotor. (Lidiana et al., 2018) As an illustration, the following is the average value of the UAS (Semester Final Examination) for applied chemistry students in semester 1 of the 2016/2017 academic year. Based on Table 1.1, it can be seen that the learning

outcomes of applied chemistry have not reached the KKM (Creteria for Completeness).

Table 1. End of Semester Test (UAS)

No.	Class	Students Number	Averages
1	TG1 (TA. 2020/2021)	4	46,72
2	TG1 (TA.2019/2020)	14	51,55
3	TG1 (TA.2018/2019)	12	48,90

Source: Researchers

This research has been carried out by many other researchers such as (Ajredini et al., 2014), entitled Real Experiments versus Phet Simulations for Better High-School Students' Understanding of Electrostatic Charging. (McKagan et al., 2008), entitled Developing and researching PhET simulations for teaching quantum mechanics. (Moore et al., 2014), entitled PhET Interactive Simulations: Transformative Tools for Teaching Chemistry. Which concludes that the simulation is accessible online, and is designed to be a flexible tool to support a variety of implementation styles and teaching environments.

Based on the problems from the observations that have been described, lecturers as educators need to create a creative innovation in applied chemistry learning. Students express their opinions and find their own problems. So, we need a PhET medium. The PhET simulation media provided is very interactive and invites students to learn by exploring directly. This PhET software contains an abstract physics animation or cannot be seen by the open eye, such as: tools and materials used in elasticity materials. For quantitative exploration, this PhET software has measuring tools in it such as pH scale, acid-based media, and others (Diraya et al., 2021). The advantage of PhET simulation is that it emphasizes the relationship between real-life phenomena and the underlying science (Widyaningsih & Yusuf, 2018). So that from these advantages it can improve student learning outcomes. Based on the problems described, the objectives of this study are; 1) Describe the use of PhET Simulation. 2) Knowing the effectiveness of using PhET Simulation media in acid-base practicum. 3) Knowing the advantages and disadvantages of using PhET Simulation in acid-base practicum. 4) The purpose of this study was to see student learning outcomes after the application of PhET media in learning.

2. RESEARCH METHOD

This study is a type of descriptive research that begins with the manufacture of PhET simulation media devices and student worksheets. The purposive sampling in this research is the first semester students who program the Applied Chemistry course at the Graphic Engineering Study Program at the State Polytechnic of Creative Media PSDKU Medan Odd Semester 2021-2022. The sample selection is to provide an understanding of the concept of the Applied Chemistry course to the Graphic Engineering Study Program students, especially in the explanation of the acid-base practicum which has never been tested directly in the laboratory. Data analysis techniques are in the form of presenting data into frequency distribution tables and histogram graphs that describe the distribution of student learning outcomes as a whole. To obtain a frequency distribution table with a perfect class length, corrections are made in determining the interval/range class in the form of initial and final scores/values using Equation (1).

$$p.k = (r+1) + X \quad (1)$$ (Widyaningsih & Yusuf, 2018)

Description:

p = class length
r = range
k = number of classes
X = score/determinant score (score/initial score and score/final score in the table)

The provisions for the value of X obtained are if:

1. X = 0, then the smallest initial score/value is taken.
2. X = 2, then 2 divided by 2 = 1 (the initial score/value taken is the smallest data minus 1, and the final score/value in the table is increased by 1).
3. X = 3, then 3 is divided by 2 = 1.5 (rounded up to 1 & 2 or 2 & 1, which matters is the number 3). If 1 & 2 are selected, then the initial score/value as a reference point is taken, i.e. the smallest data is reduced by 1 and the final score/value in the table will be increased by 2, and vice versa (Widyaningsih & Yusuf, 2018).

The X value obtained in equation (1) is then determined by class intervals and further analyzed using the SPSS version 20 program. The assessment of student learning outcomes after the application of PhET media is categorized as in Table 2.

Table 2. Score Interpretation Criteria

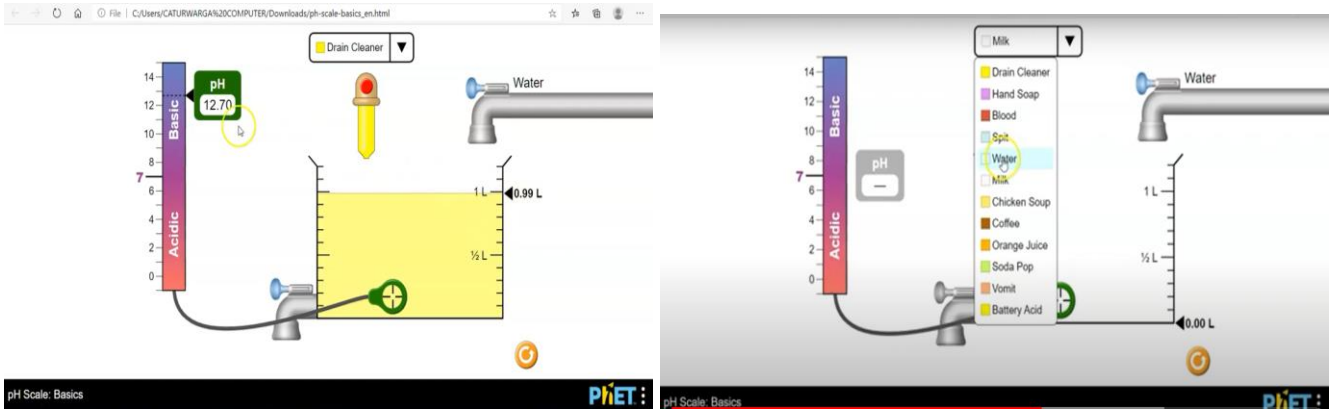
Percentage (%)	Predicate
0-25	Very less
26-50	Not enough
51-75	good
76-100	Very good

Source: (Widyaningsih & Yusuf, 2018)

3. RESULTS AND DISCUSSION

3.1 Results

The PhET simulation media in the acid and base practicum consists of a simulation device in the form of experiments to determine the pH of acid-base products in everyday life that can be run virtually as shown in Figures 1. The PhET simulation media used can run experiments virtually. The use of computer simulations that can run experiments virtually is very well applied in learning (Widyaningsih & Yusuf, 2018).



Figures 1. Acid Base PhET Simulation Display

The PhET simulation media used is equipped with a Student Worksheet (LKM) containing procedures, filling in the results of observations, data analysis, and evaluation in the form of questions related to the acid-base material contained in the PhET simulation. The use of the LKM is intended to direct students in carrying out PhET simulations so that there are no errors in data collection. According to Yusuf et al., (2015) that the use of simulation media assisted by worksheets oriented to thinking skills can develop student learning activities. Furthermore, according to Nurliawaty et al., (2017) that the use of thinking skill-oriented worksheets is effective in developing students' ability to solve problems.

Assessment of student learning outcomes after learning using PhET simulation media can be presented in the form of a frequency distribution by determining the class interval using equation (1) so that a perfect initial and final score / value is obtained. Based on these calculations, further data analysis was carried out using the SPSS version 20 program so that the analysis results were obtained in **(Table 3)**.

Table 3. Frequency Distribution of Student Learning Outcomes

Interval class	Frequency	Valid (%)	Cumulative Percents
23-37	4	8,2	8,2
38-50	7	21,4	29,6
51-65	13	35,2	64,8
66-81	5	26,5	91,3
82-94	3	8,7	100,0
Total	32	100,0	

Based on **Table 4**, it can be seen that most of the students' scores, namely 13 people, were in the 51-65 interval, while at the lowest interval, 4 people were at least among the other intervals. This shows that the condition of student learning outcomes is more likely to be in the high category. The high learning outcomes of students indicate their high thinking ability in understanding the subject matter (Tanujaya, 2016). Based on the assessment, it was found that students who were in the low category were those who were less active in learning, especially in conducting virtual experiments using PhET media. Therefore, it is very important for teachers to organize heterogeneous groups. The formation of heterogeneous groups is intended so that students with high abilities can share with those with low abilities so that various interactions occur in order to build their understanding of the material being studied. Students' activities in learning include the process of constructivism, namely they are expected to be able to build their understanding of the subject matter (Mumu et al., 2017). This is the accompaniment impact of the learning objectives, namely in addition to achieving learning objectives directly, they can also develop good characters such as cooperation, mutual respect and responsibility. As according to Pangkal et al., (2016) that group learning such as cooperative learning can foster mutual cooperation and a sense of responsibility as well as good interaction between students.

ie 62 ± SD 18 or in the good category which indicates that the application of PhET media is effective for electric and magnetic materials. According to Gündoğdudkk., (2011) that the use of computer simulation is effectively applied in learning, it makes it easier for teachers to present material and develop students' understanding of the concepts of the material being studied. Furthermore, Sumargo & Yuanita (2014) revealed that the use of PhET simulation is a new thing for students which can increase learning motivation. Prihatiningtyas et al., (2013) also confirmed that the application of PhET simulation in learning can improve students' psychomotor learning outcomes.

Discussion

Based on the results of interviews with students after learning, it was found that students enjoyed learning by using PhET media. They can further explore the experiments carried out without worrying about damaging the equipment than if they were carried out directly in a real laboratory. As according to Setiadi & Muflika, (2012) that the use of PhET simulation that supports virtual experiments can develop students' skills in experimenting as well as a solution in overcoming the limitations of experimental facilities and infrastructure in real laboratories. using PhET media simulation can protect students when they are dealing with hazardous (chemical) materials, provide a realistic learning experience (rather than asking students to make assumptions or memorize concepts and procedures), help solve the problem of lack of ability on campus, helping lecturers evaluate students IT, helping students, especially in the early stages, to overcome boredom because of the theoretical sciences they learn on campus, and allows students to experiment more than once without being limited by space and time. (Prasetyo, 2022).

4. CONCLUSION

Based on the purpose and discussions, it is concluded that the application of PhET simulation is effectively applied to the Applied Chemistry course in the Graphic Engineering Study Program with a good category and the learning outcomes obtained by students are 65 ± SD 18. Based on the assessment of student responses after learning it is found that students are very happy to learn by using PhET media.

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AUTHOR'S CONTRIBUTIONS

The authors discussed the results and contributed to from the start to final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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