Utilization of the Android physics virtual lab application to improve understanding of light and optics concepts

M Erfan1, M A Maulyda1*, V R Hidayati1, A Widodo1 and T Ratu1

1Universitas Mataram, Indonesia
2Universitas Samawa, Indonesia

*archimaulyda@unram.ac.id

Abstract. This research aims to analyze the effectiveness of the application of virtual laboratories based on android applications on the learning outcomes of prospective elementary school teacher students about light and optics concept in daily life. This research is a quantitative with one group pre-test post-test design. The treatment given was in the form of learning about light and optics concepts using the Android Physics Virtual Lab application. The sample in this study was taken using cluster random sampling technique and obtained class 5H (24 students) as the sample. The data in this research were obtained by tests carried out before treatment (pre-test) and after treatment (post-test). The data from pre-test and post-test result were tested for normality, then paired t-test, N-gain test and Effect Size test were performed. The N-gain test value that have been obtained was 0.784 (high category) and the coefficients of effect size test results was 1.781 with the strong effect category and from the t-test results there was significant difference between students' understanding of concepts light and optics before and after learning. with the Android Physics Virtual Lab application, so from this study it can be concluded that the Android Physics Virtual Lab application is effective in enhancing students' understanding about light and optics concepts of prospective elementary school teachers.

1. Introduction

Basic Concepts of Natural Science is one of the compulsory courses that must be studied by prospective primary school teacher students [1]. This course examines basic science concepts and their applications in everyday life. This course aims to make prospective elementary school teacher students have the ability to develop students’ knowledge and understanding about science concepts that can be used and can be applied in everyday life, develop their curiosity, and have sufficient competence about the basic concepts of science at the primary school level [2].

One of the important science concepts to be taught at the primary school level is the concept of light and optics. In the concept of light, students learn about the properties of light which includes light propagating in a straight line, the nature of light can be reflected, can be refracted, can be diffracted, and light can experience interference. In optical concepts, students learn about the workings of various optical devices, analogies of eyes and cameras, and the process of seeing objects. All of these concepts will be easier to grasp by students if the teaching and learning process is carried out through demonstrations in the laboratory through practicum activities.
The covid-19 pandemic not only caused a change in teaching and learning activities from offline to online, but also disrupted practicum activities that should have been carried out in the laboratory. Practical activities need to be carried out in the laboratory because in the laboratory there are various tools and materials that support practicum activities so that various science concepts can be demonstrated directly. Through practicum activities, besides students can experience the nature phenomena, students can prove existing concepts or theories and can experience the process or experiment itself, then draw conclusions, so that they can support students’ understanding of course material [3].

Generally, one of the practicum activities on the concept of light and optics are the forming process of images on lenses and mirror, is carried out by means of an optical table, a set of lenses with a certain focus distance, a light source, and a screen or a wall that can vary the distance from the lens. There are many concepts related to the process of images formation on lenses and mirrors that should be learned in practicum activities, one of which is the process of running the light if an object is at the focal point which mostly makes it difficult for prospective elementary school teacher students to grasp. With the Covid-19 pandemic which requires someone to do social distancing, educators must find other ways so that practicum activities regarding light and optics can still run.

One of the many efforts that educators could make in teaching of the concepts of light and optics is to use a virtual laboratory. Virtual lab is a computer program designed to simulate the real life laboratory works and experiment [4]. Through virtual laboratory, simulation of a complex condition, too expensive or too dangerous experiment if carried out in real conditions, can be carried out using a virtual laboratory [5]. Especially in virtual science lab, students can collect real data from remotely controlled instruments and explore them using simulated ones, such as the virtual microscope that uses high-resolution images instead of actual specimens [6], [7].

The latest breakthrough in a virtual laboratory for light and optical materials is a virtual laboratory based on an android application. One of the android applications that can simulate the path of rays in the process of forming a shadow is Physics Virtual Lab. This application can be downloaded for free on the Play Store. This application includes various simulations such as light and optics, mechanics, electricity and magnetism, waves, thermodynamic, and quantum mechanics. In addition, the Android application as a simulator has other advantages, namely portability and high compatibility. The portability aspect allows users to simulate light and optics anytime and anywhere [7]–[11], for compatibility, this application can be installed on smartphones with Android OS version 3.0 up to the latest version and can be run on a Personal Computer (PC) if the PC desktop is installed the Android emulator.

2. Methodology
This research is a descriptive quantitative research with one group pre-test post-test design. The treatment given was in the form of learning the concept of light and optics about forming images on mirrors and lenses using the Android application (Physics Virtual Lab). The sample in this study was taken using cluster random sampling technique and obtained class 5H (24 students) as the sample. The data in this study were obtained by tests carried out before the treatment as we call it the pre-test, and after the treatment or post-test. The data from pre-test and post-test result were tested for normality, then the N-gain test and Effect Size test were performed. The high and low N-gain test results are categorized into three categories (high, moderate, low) which are presented in Table 1 [12],[13]. The category effect size test results are presented at Table 2.

| Criteria for Increasing Gain Value | Normalized Gain Value |
|-----------------------------------|-----------------------|
| High Gain                         | g ≥ 0,7               |
| Moderate Gain                     | 0,3 ≤ g < 0,7         |
| Low Gain                          | g < 0,3               |
Table 2. Effect Size Interpretation Criteria [15]

| Size     | Interpretation |
|----------|----------------|
| 0 – 0.20 | weak           |
| 0.21 – 0.50 | modest     |
| 0.51 – 1.00 | moderate   |
| > 1.00   | strong         |

3. Result and Discussion

Increasing understanding of light and optics concepts about the image’s formation process on lenses and mirrors is done by using the Android *Physics Virtual Lab* application. Simulation of the path of incident rays and reflective rays in images formation on lenses and mirrors is one part of the menu options in this application, besides this application can simulate various concepts of light, there are also other menus, namely simulations on mechanics, electricity, and magnetism, waves, thermodynamics, and quantum mechanics.

![Figure 1. Display of the physics virtual lab android application](image)

In the Light simulation menu as in Figure 1, it is further divided into several submenus such as convex mirrors, concave mirrors, convex mirror focal points, concave mirror focal points, convex lenses, concave lenses, concave focus points, convex lens focus points, reflection law, flat mirrors, refraction on a plane, the image on two flat mirrors that form an angle, reflection on the prism, Newton’s color wheel, and simulation of the viewing process on a telescope. Images formation process on lenses and mirrors can be simulated interactively by shifting the distance of virtual object and adjusting the distance of lenses or mirrors focal length. Based from Figure 1, this application does not simulate the thickening and thinning of the lens or mirror pieces from the change in the size of the focal point. Through this application, understanding the concept of the process of forming images on mirrors and lenses can be applied virtually and can be done anytime and anywhere (portable).

Understanding the concept of elementary school teacher prospective students regarding the images formation process on lenses and mirrors can be referred from the result of pre-test and post-test scores. The results of descriptive statistics on the pretest scores of prospective primary school teacher on the concept of light and optics about images formation process on lenses and mirrors can be seen at Table 3.
Table 3. Descriptive Statistics of Pretest and Posttest Values

| Descriptive Statistics | Pretest | Posttest |
|------------------------|---------|----------|
| Mean                   | 48.96   | 88.96    |
| Median                 | 47.50   | 88.75    |
| Maximum                | 72.50   | 100.00   |
| Minimum                | 32.50   | 75.00    |
| Std. Dev               | 11.98   | 7.26     |

Based on Table 3, it can be seen there is a difference in the mean of students understanding regarding images formation process on lenses and mirrors where the post-test average was 88.96 and higher than the pretest average (48.96). Before normalized Gain test, the normality test was carried out on the pretest and posttest values. The results of the normality test obtained a significance value (Sig.) At the pretest was (0.225) and the significance value at the posttest was (0.081). Based on the two significance values which are both greater than 0.05, it can be seen that the pretest and posttest values are both normally distributed so that a paired sample t test can be done to find out how significant the average pretest and posttest.

The paired sample t-test results obtained a t-count value of 27.416 which is much greater than the t-table (2.068) so that there is a significant difference between the average pretest and posttest mean values. The normalized gain test results obtained a gain value of 0.784. Based on the criteria for the Gain value in Table 1, the gain value of 0.784 is included in the high category. The results of the effect size test obtained a size value at 1.781, far above 1.00, so that it is included in the category of having a big effect on understanding the concept of prospective elementary school teacher students.

The increased understanding of the concept of images formation process on lenses and mirrors after learning with virtual laboratories is in line with other studies where virtual laboratory-based learning can improve students' mastery of concepts on dynamic electricity topics [16], [17]. The use of Android-based virtual laboratories that are supported by high portability can improve learning outcomes and students' ability to think creatively [18]–[24].

Android application-based virtual laboratories can be an alternative for students, especially in the process of planting the concept of images on lenses and mirror in prospective elementary school teachers [13]. Apart from the Android Physics Virtual Lab application, users can also download various other simulation applications for free and of course it is supported by the portability of a more mobile Android application so that it can be used anytime and anywhere.

4. Conclusion

From this research, it can be concluded that the use of the Android application in form of Physics Virtual Lab is effective in increasing the understanding of the concept of prospective elementary school teacher students on the topic of light and optics about the image’s formation in mirror and lenses.

References

[1] Y. F. Surya and R. Marta, “Analisis Kesulitan Belajar Mahasiswa PGSD STKIP Pahlawan Tuanku Tambusai Pada Mata Kuliah Konsep Dasar IPA SD,” J. Basicedu, vol. 1, no. 2, pp. 1–11, 2017.
[2] N. Nurhairani, “Pendekatan Keterampilan Proses pada Mata Kuliah Konsep Dasar IPA SD,” JS (Jurnal Sekolah), vol. 2, no. 2, pp. 1–8, 2018.
[3] I. A. Muna, “Analisis Pelaksanaan Kegiatan Praktekum IPA di Prodi Pendidikan Guru MI Jurusan Tarbiyah STAIN Ponorogo,” KODIFIKASIA, vol. 10, no. 1, pp. 109–131, 2016, doi: 10.21154/kodifikasia.v10i1.810.
[4] H. E. Keller and E. E. Keller, “Making Real Virtual Labs,” Sci. Educ. Rev., vol. 4, no. 1, pp. 2–11, 2005.
[5] R. R. Nirwana, “Pemanfaatan Laboratorium Virtual dan E-Reference dalam Proses Pembelajaran dan Penelitian Ilmu Kimia,” *J. Phenom.*, vol. 1, no. 1, pp. 115–123, 2011.

[6] M. M. Waldrop, “Education online: The virtual lab,” *Nat. News*, vol. 499, no. 7458, p. 268, 2013.

[7] K. Aljuhani, M. Sonbul, M. Althabit, and M. Meccawy, “Creating a Virtual Science Lab (VSL): the adoption of virtual labs in Saudi schools,” *Smart Learn. Environ.*, vol. 5, no. 1, p. 16, Dec. 2018, doi: 10.1186/s40561-018-0067-9.

[8] R. Bose, “Virtual Labs Project: A Paradigm Shift in Internet-Based Remote Experimentation,” *IEEE Access*, vol. 1, pp. 718–725, 2013, doi: 10.1109/ACCESS.2013.2286202.

[9] B. Balamuralithara and P. C. Woods, “Virtual laboratories in engineering education: The simulation lab and remote lab,” *Comput. Appl. Eng. Educ.*, vol. 17, no. 1, pp. 108–118, Mar. 2009, doi: 10.1002/cae.20186.

[10] G. Narayanan and A. Deshpande, “Learning Automation Made Easy through Virtual Labs,” in *2016 International Conference on Learning and Teaching in Computing and Engineering (LaTICE)*, Mar. 2016, pp. 60–65, doi: 10.1109/LaTiCE.2016.17.

[11] R. Radhamani, H. Sasidharakurup, G. Sujatha, B. Nair, K. Achuthan, and S. Diwakar, “Virtual Labs Improve Student’s Performance in a Classroom,” 2014, pp. 138–146.

[12] K. K. Cheng, B. A. Thacker, R. L. Cardenas, and C. Crouch, “Using an online homework system enhances students’ learning of physics concepts in an introductory physics course,” *Am. J. Phys.*, vol. 72, no. 11, pp. 1447–1453, Nov. 2004, doi: 10.1119/1.1768555.

[13] M. Erfan, M. A. Mauluya, G. Gunawan, N. Sari, and T. Ratu, “Enhancing Students Ability in Analyzing Image Formation on Lens and Mirror Using Ray Optics,” *J. Phys. Conf. Ser.*, vol. 1471, p. 012061, Feb. 2020, doi: 10.1088/1742-6596/1471/1/012061.

[14] R. R. Hake, “Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses,” *Am. J. Phys.*, vol. 66, no. 1, pp. 64–74, Jan. 1998, doi: 10.1119/1.18809.

[15] L. Cohen, L. Manion, and K. R. B. Morrison, *Research Methods in Education*. Routledge, 2007.

[16] G. Gunawan, A. Setiawan, and D. Widyanoto, “Model Virtual Laboratory Fisika Modern untuk Meningkatkan Keterampilan Generik Sains Calon Guru,” *J. Pendidik. dan Pembelajaran*, vol. 20, no. 1, pp. 25–32, 2014.

[17] N. Hikmah, N. Saridewi, and S. Agung, “Penerapan Laboratorium Virtual untuk Meningkatkan Pemahaman Konsep Siswa,” *EduChemia (Jurnal Kim. dan Pendidikan)*, vol. 2, no. 2, p. 186, Jul. 2017, doi: 10.30870/educhemistry.v2i2.1608.

[18] D. Mohamad Nurdin, D. Darmawan, and H. Hernawan, “EFEKTIVITAS PENGGUNAAN MULTIMEDIA INTERAKTIF DAN MOBILE LEARNING DALAM MENINGKATKAN HASIL BELAJAR PADA MATA PELAJARAN MATEMATIKA,” *PEDAGOGIA*, vol. 14, no. 1, p. 86, Aug. 2016, doi: 10.17509/pedagogia.v14i1.2341.

[19] E. Rosiska, “PEMANFAATAN APLIKASI VIRTUAL LEARNING BERBASIS ANDROID DALAM MENINGKATKAN KUALITAS PEMBELAJARAN,” *J. Pengabdi. Barelang*, vol.
1, no. 01, p. 29, Jan. 2019, doi: 10.33884/jpb.v1i01.979.

[23] M. R. Palevi, P. A. Saputri, and R. Vebrianto, “Ruang kelas virtual: pembelajaran dengan pemanfaatan permainan online Hago,” *JPPI (Jurnal Penelit. Pendidik. Indonesia)*, vol. 6, no. 1, p. 7, Jun. 2020, doi: 10.29210/02019410.

[24] H. K. Sari, H. Harjono, W. Sumarni, and M. Nuswowati, “KONTRIBUSI VIRTUAL LABORATORY PADA PEMBELAJARAN TITRASI ASAM-BASA DENGAN PREDICT-OBSERVE-EXPLAIN TERHADAP HASIL BELAJAR DAN KETERAMPILAN BERPIKIR KRITIS,” *Phenom. J. Pendidik. MIPA*, vol. 9, no. 2, p. 190, Jun. 2020, doi: 10.21580/phen.2019.9.2.3994.