UNIVERSITI PUTRA MALAYSIA

EVALUATING RECORDED LABORATORY VIDEO DEMONSTRATION USING IMAGEJ SOFTWARE IN IDENTIFY CUBIC SYSTEM AND DETERMINATION FOR INDEXING HKL PLANE THROUGH STUDENT PERCEPTIONS

CHAN YING YI

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By

CHAN YING YI

198152

Thesis Submitted to the Department of Physics, Universiti Putra Malaysia, in partial Fulfilment of the Requirements for the Degree of the Requirements for the Degree of Bachelor of Science in Instrumentation Science with Honors
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ABSTRACT

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Supervisor: Raba'ah Syahidah Azis (Prof. Madya. Dr.)

Faculty: Physics, Faculty of Science

In this project, the video demonstrations of two (2) laboratory experiments were produced which are Identify a Cubic System and Determination for Indexing the hkl plane. The experiment was done using the ImageJ software and it was recorded as a video lab demonstration. The level of understanding towards laboratory demonstration video using ImageJ on analysis of structure for universities students was surveyed via questionnaires as the research instruments. The performance data of the students' understanding shows how students can understand the recorded lab video and carry this experiment on their own. In this study, 30 students from various courses were recruited to assess their comprehension of the laboratory experimental video. Students benefit from online demonstration videos, but it also has drawbacks. Although face-to-face experiments provide greater laboratory experience than online experiments, more than half of students feel that lab video demonstrations are still extremely helpful in completing the course's lab assignment. The majority of them are able to comprehend what is being given in the movie, and the instructions are simple to follow.

ABSTRAK

MENILAI DEMONSTRASI VIDEO MAKMAL YANG DIRAKAM MENGGUNAKAN PERISIAN IMAGEJ DALAM MENGENAL PASTI SISTEM KUBIK DAN PENENTUAN UNTUK MENGINDEKS HKL MELALUI PERSEPSI PELAJAR

CHAN YING YI

(198152)

Januari 2022

Penyelia: Raba'ah Syahidah Azis (Prof. Madya. Dr.)

Fakulti: Physics, Fakulti Sains

Dalam projek ini, dua (2) eksperimen makmal telah dihasilkan dalam bentuk video demonstrasi iaitu Mengenalpasti Sistem Kubik dan Penentuan untuk Mengindeks nilai hkl. Eksperimen telah dilakukan menggunakan perisian ImageJ dan direkodkan sebagai demonstrasi makmal video. Tahap kefahaman terhadap video demonstrasi makmal menggunakan ImageJ dalam analisis struktur pelajar universiti telah ditinjau melalui soal selidik sebagai instrumen kajian. Data prestasi pemahaman pelajar menunjukkan bagaimana pelajar boleh memahami video makmal yang dirakam dan menjalankan eksperimen ini sendiri. Dalam kajian ini, 30 pelajar dari pelbagai kursus telah diambil untuk menilai kefahaman mereka terhadap video eksperimen makmal. Pelajar mendapat manfaat daripada video demonstrasi dalam talian, tetapi juga mempunyai kelemahannya. Walaupun eksperimen bersemuka memberikan pengalaman makmal yang lebih hebat daripada eksperimen dalam talian, melebih separuh daripada pelajar merasakan demonstrasi video makmal masih sangat membantu dalam menyelesaikan tugasan makmal kursus. Majoriti daripada mereka dapat memahami apa yang diberikan dalam video dan arahannya mudah diikuti.

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Apart from my supervisor, I would like to thank my lab mates in the laboratory at the Faculty of Science, UPM Serdang: Nurhanis Syahirah binti Adnan, Siti Darwishah Balqis binti Rosle and Muhammad Nazhiif bin Haron for the discussions and also the time we spent together on this research.

Last but not least, I would like to express my gratitude to my family, particularly my parents, for giving birth to me and supporting me throughout my life.

Date: …….

Assoc. Prof. Dr. Suriati Paiman

Head of Department

Department of Physics

Faculty of Science

Universiti Putra Malaysia

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LIST OF ABBREVIATIONS

hkl	Miller Index
SC	Simple Cubic
BCC	Body-Centered Cubic
FCC	Face-Centered Cubic
FFT	Fast Fourier Transform

CHAPTER 1

INTRODUCTION

1.1 Introduction of Lab Course PHY4204

Video demonstrations for laboratories are frequently employed in many schools and universities in this current technological age. The pre-recorded tutorials have three objectives which are:

i. To introduce equipment and explain the objectives of each experiment

ii. To demonstrate any special techniques used in performing the experiment

iii. To show where various valves, switches, meters, and other instrumentation used in the experiment are located.

The videos are meant to augment, not replace, each experiment's written instructions and guidelines. Having additional audio and visual instruction for these experiments should benefit students in different learning styles as well as provide clarification regarding the placement of process lines and instrumentation in the experimental apparatus.

The course PHY4204 Analytical Methods of Structure and Microstructure is a continuation of PHY3201 Solid State Physics. There are seven labs for this course. Introduction to XRD Technique, Symmetry, Determine Crystalline State, Identify a Cubic System, Determination of hkl plane, Determine of Lattice Parameter, and Determine of Surface Morphology are the seven labs for this course.

1.2 General Introduction

Due to this pandemic of Covid-19, all classes, including the lab component, must be completed online. As a result, every lab must be converted to an experiment that can be completed online. This thesis will show lab demonstrations and results by using video. For this lab demonstration, ImageJ software will be employed that will allow students to access and complete them on their own using an online method. Because open-source software may be freely reviewed, improved, and redistributed, it is perfect for scientific activities; in particular, the open-source platform ImageJ has had and continues to have a tremendous impact on the life sciences.

The unit cell is defined as the smallest repeated unit with full crystal structure symmetry. Unit cell exist in many type. There is 3 distinct type of the cubic crystal structure unit cell which are Primitive Cubic Unit Cell, Body-centered Cubic Unit Cell and Face centered Cubic Unit Cell.

1.2.1 Simple Cubic (SC)

For simple cubic lattice, it consists of the lattice points identified by the corners of closely packed cubes. The simple cubic lattice contains 1 lattice point per unit cell. The unit cell is the cube connecting the individual lattice points. All hkl value is available for SC.

1.2.2 Face-Centered Cubic (FCC)

For face-centered cubic lattice, it is the same as simple cubic lattice but with the addition of a lattice point in the center of each of the six faces of each cube. The face-centered cubic lattice contains 4 lattice points per unit cell. The maximum packing density occurs when the atoms have a radius that equals one-quarter of the diagonal of one face of the unit cell. The h+k+l value for FCC is all in even number.

1.2.3 Body-Centered Cubic (BCC)

For body-centered cubic lattice, it is the same as simple cubic lattice but with the addition of a lattice point in the center of each cube. The body-centered cubic lattice contains 2 lattice points per unit cell. The maximum packing density occurs when the atoms have a radius that equals one-quarter of the body diagonal of the unit cell. The h+k+l value for BCC is all in even or all odd number.

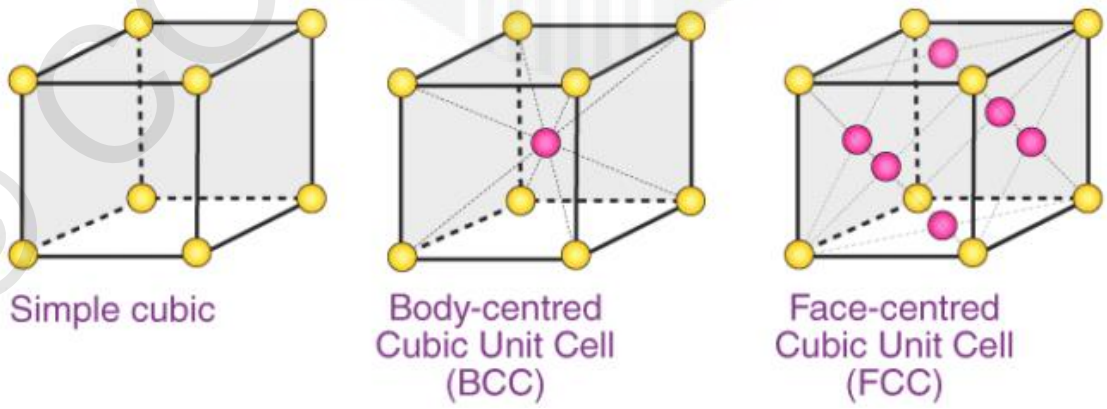


Figure 1.1: Structure for simple cubic lattice, body-centered cubic lattice and face-centered cubic lattice. (BYJU'S, 2022)

1.3 Benefit of Online Lab Learning

An online lab learning, which is also known as virtual lab learning, is an on-screen simulator or calculator that assists in the testing and observation of ideas. According to Luka Ngoyi, (2013), there are several benefits associated with online learning.

Firstly, it has a more flexible time when doing online lab compare to face to the face lab class. The student can do their lab anytime, unlike the case that students only have a 2-hour limit to do their lab. Students usually cannot stay too long time in laboratories because there might be other classes that need to use the lab. Other than that, the lab will be closed after working hours. With this online lab, students can access the lab using the application installed in the computer at any time even during nighttime.

Secondly, every student can have the chance to experiment on their own. Mostly, students will do their experiment in a lab in a group form. This is because there is a limited apparatus in laboratories. By using the software application provided, students can access it using their laptop.

Besides that, low costs spend are also one of the benefits of the online lab. There is a fee associated with using virtual labs but the capital and maintenance costs are drastically reduced. Instead of one laboratory footing the bill for resources, the cost is split among the clients of the particular virtual lab. This enables the lab to provide a better learning environment for students

at a lower cost.

Lastly, online lab can ensure the safety of the students. The online lab can protect students from the dangers they face while conducting some dangerous laboratory experiments. It also avoids the need to deal with toxic/radioactive substances and other comparable concerns, as well as providing a reliable method of avoiding laboratory mishaps.

1.4 Problem Statement

Due to the Covid-19 pandemic, many school and university programmes, including the experiment class, have been forced to switch to online classes. Online classes have also become one of the most significant components of advancing in the country as technology advances in the twenty-first century.

Even if some paper work is concerning online laboratory video, there aren't many of these types of paper thesis available. There is not much thesis work that examines students' perceptions of online classes and video lab example. This project is about an online laboratory that needs to be completed and documented in the form of a video, as well as a test of students' understanding of it.

There is some challenge in producing video for lab demonstration. Firstly, the lab video presentation must be clear and understandable to all students. An excellent video should allow

students who have never taken this course before to understand the topics presented in the video. Secondly, the assessment of using ImageJ to acquire the particle's microstructure is also a challenge for this investigation. This is because to make sure that receive good data from the experiment before making the video to show it to them. Lastly, the thesis's challenges may be the procedure of creating a video lab demonstration. The editing and merging of the video takes time to complete. The video need to be interactive enough to let students having more interesting in learning.

1.5 Objective

The objectives for this study are

1. To video demonstrate two (2) laboratory for PHY4204 course which are identify the cubic system and determination for indexing hkl plane.
2. To determine the structural and microstructural analysis using ImageJ software.
3. To evaluate the effectiveness of the video by analysing the feedback form through student perceptions.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Nowadays, technology is now born as a result of scientific advancements and accomplishments. Technology is described as the application of information in the design and development of devices and equipment that may be employed in a number of applications. Technology has become an integral part of everyone's daily routine. As a result of the pandemic of Covid-19, people came up with the idea of online education.

The literature review for the online lab was presented in this chapter. This chapter will also cover the previous work of the ImageJ software programme will be discussed. Finally, in the last section of this chapter, feedback from previous thesis based on the benefits and effectiveness of video techniques.

2.2 Online Laboratory Learning

Virtual laboratories are a way that allow students to practise experiment in a safe and online environment. Students can engage with elements, machines, and interfaces via virtual scientific lab games and engineering simulation software before or instead of evaluating them in real life. Virtual labs are one of the most essential e-learning strategies tools because they allow professors and students to achieve the goals of the educational process objectives. (Mostafa Elhashash, 2020)

The first version of the Virtual Laboratory, dubbed Virtual Laboratory of Physiology, which was released in 1977. Dierig, Sven; Kantel, Jörg; Schmidgen, Henning (2000) state that the Internet's public launch in the early 1990s, scholars working in the historical sciences, the history of science, and science and technology studies have become increasingly reliant on it. In year 1999, the emphasis had switched away from physiology and toward the realm of life sciences in general, as well as the arts and literature. After that, the first online laboratory was invented online in year 2002.

According to Woodfield et al. (2004), the primary goals of instructional laboratory sessions were to teach laboratory procedures and analytical thinking abilities, as well as to establish a strong link between theory and laboratory practise. Luka Ngoyi, (2013) claims that many educational institutions are using virtual labs on their campuses in addition to using them in distance learning, and they are being scrutinized in the same way that those that use them in

distant education are. Since online laboratories are used all over the world, there are numerous advantages as well as disadvantages to doing an online lab.

The advantage of online lab leaning is students has flexible time for lab learning. For flexibility, it is adaptability with students being able to enroll in a class at any time. It is the flexible nature which serves to attract learners who usually have strict schedules at their places of work and cannot manage to attend the regular school setting (Farrel, 1999). Unlike classroom-based learning, students can enroll in a course at any time in virtual learning (Koller, Harvey, & Magnotta, n.d.). Students can access the lab via the application placed on their computer at any time, including at night, with this online lab. This also allows students to own the learning process because they are in charge of it, and it gives them motivation to be self-sufficient (Sparrow, Sparrow, & Swan, 2000). It would be able to better combine employment, life, and graduate school with this flexibility.

For collaboration, virtual learning also gives opportunities for students to learn in groups, thereby rendering them to be more active participants in the learning as they engage in critical thinking and problem-solving activities (Brindley, Blaschke, & Walti, 2009). Shared ownership of learning can lead to strong ties amongst students, which can aid in the creation of knowledge and the development of critical thinking skills (Brookfield, 1995; Christiensen & Dirkinick-Holmfeld, 1996). Kelsey Miller (2019) stated that learning to work with others in a virtual environment can make you a more effective leader. Utilizing specialist information, building efficient processes, and making decisions regarding best communication techniques, such as

what should be communicated in person or electronically, will make someone acquire important leadership abilities.

One of the most significant benefits of online learning is that professionals can learn from colleges all over the world and select the curriculum that best suits their needs without having to relocate their lives. For providing high-quality learning opportunities and educational choice, since every resource can be found online by simply logging on to a computer that is connected to the internet, it has become easy for students learning virtually to access to materials and even interact with subject-matter experts in relevant fields of their learning from any location 35 in the world (Twigg, 1995). This ensures that students can complete their learning duties at any time and that they have the opportunity to overcome the barriers posed by physical location in order to obtain the education they desire (Barbour & Reeves, 2009).

Even there are many advantage for online learning, there is also some disadvantage through it. Technology issues is the disadvantage of online learning. This will be a difficulty for students because doing an online lab requires advanced technology. Students who are unfamiliar with technology may perceive their virtual programmes as a technological burden, particularly if they require significant technological manipulation (Luka Ngoyi, 2013). JiĜí Zounek & Petr Sudický, (2012) said that students who lack sufficient desire and the skills to arrange their workload and learn autonomously may hold grudges against technology-enhanced learning. There can be a loss of continuity in learning for students if they do not have access to the internet on a regular basis. This has a negative impact on the educational process.

Other than that, students may inability and struggle to focus on screens during having a long period of time. Valentina Arkorful and Nelly Abaidoo (2014) agreed that with online learning, students are also more likely to be quickly distracted by social media or other websites. When compared to their peers, students who lacked self-motivation and independence had lower success rates (Sarkar, 2012). Learners who lack self-control are more likely to not allot enough time to complete projects, resulting in poor quality work or late assignments (Al Rawashdeh, A. Z., et al., 2021).

Online learning is a powerful instrument for knowledge transfer that has the potential to replace traditional educational methods. Learners benefit from online lab learning training in the classroom. The issue about the benefits and drawbacks of online technology in education is complicated and far from black-and-white. According to Al Rawashdeh, A. Z., et al., 2021 to the conclusions of the study, e-learning has proven beneficial to its users in a variety of ways. Chu (1999) stated that virtual lab must have interactivity in order to be successful, as each topic must be provided to students in the form of exercises, which then push the students to solve the challenges they encounter while performing their lab. To summarise, it appears that the ideal approach to education technology deployment is to take a broad, open-minded approach, monitoring the general social practises of using online resources in real-life circumstances and reflecting the best practises in the learning environment (JiĜí Zounek & Petr Sudický, 2012).

2.3 ImageJ Software Application

For this report, the software application that needs to use for the student to do their experiment is ImageJ. This section had discussed about the previous work paper that had done their experiment using ImageJ software application. There are some of paper that had done a research using ImageJ software but in different field.

ImageJ is the program that will be used to test the microstructure and crystal structure of the particles. ImageJ is an open-source image processing program, which is highly extensible, and with its thousands of plugins it can reform a wide variety of tasks and that's why it is a very useful tool for the scientific community (Abramoff, M.D., Magalhaes, P.J., Ram, S.J, 2004). From its inception, ImageJ has grown significantly due largely to being freely available and its vibrant and helpful user community. (Schindelin, J., Rueden, C. T., Hiner, M. C., & Eliceiri, K. W., 2015). It is a Java-based program that is developed at the National Institutes of Health.

ImageJ can be used to display, annotate, edit, calibrate, measure, analyze, process, print, and save raster (row and column) image data. (SERC-Carleton, 2021). It reads most common raster image formats as well as raw data files in text format, such as from spreadsheets. ImageJ also can calculate the area and pixel value statistics of user-defined selections. It can measure distances and angles. It can create density histograms and line profile plots. It supports standard image processing functions such as contrast manipulation, sharpening, smoothing, edge detection and median filtering.

Preoyati Khan, (2017) had done a work using ImageJ software. He used ImageJ software for the created technology which can provide ImageJ with cluster-based image processing. He created a few supporting plugins that can correct the findings from individual cluster nodes and combine them to produce a very accurate aggregate result. Split technique was taken to complete the image as an input and splits it based on the user-specified dimension (S. Szenasi, 2013). The essential ideas underpinning the various picture segmentation approaches, including the classic split-and-merge methodology, are described in Robert M. Haralick and Linda G. Shapiro's (1985) publication. The output of these little photos is combined together to obtain the final result once they are executed in cluster nodes.

Figure 2.1: The method of counts correct number of duplicate objects with input images of spherical objects. (Preoyati Khan, 2017)

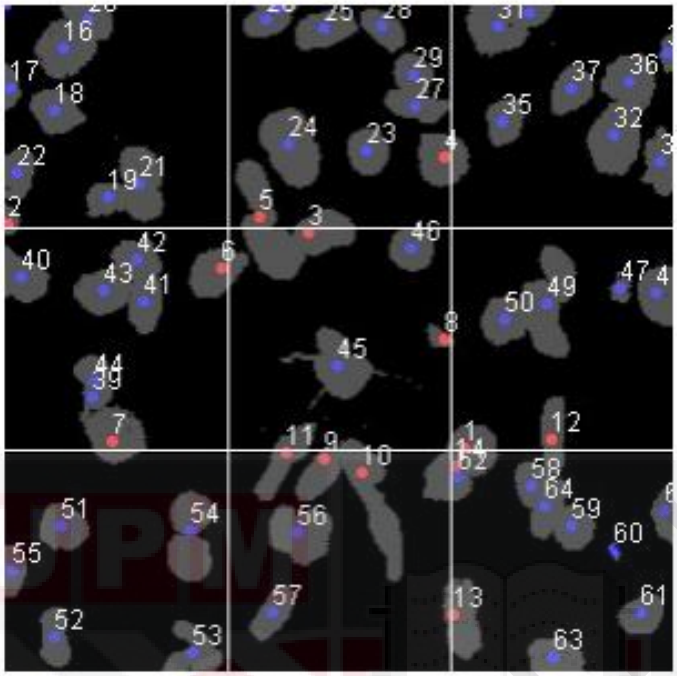


Figure 2.2: Sample Output with marked duplicated objects after z projection.

(Preoyati Khan, 2017)

Schindelin, J., Rueden, C. T., Hiner, M. C., & Eliceiri, K. W. (2015) also had done a research using ImageJ software application. They had done a research on open platform for Biomedical ImageJ Analysis. Computer vision professionals created specialised approaches that could be applied to biomedical images as the discipline of image processing progressed (Castleman, 1996). Schindelin. J and his friends explore on how it affects the life sciences, how it inspires other initiatives, and how it is influenced by other projects in the ImageJ ecosystem. A number of reviews have been produced on biomedical image processing and analysis tools in general (Eliceiri et al., 2012) and on tools to do specific tasks (e.g., Pham et al., 2000; Meijering et al., 2006).

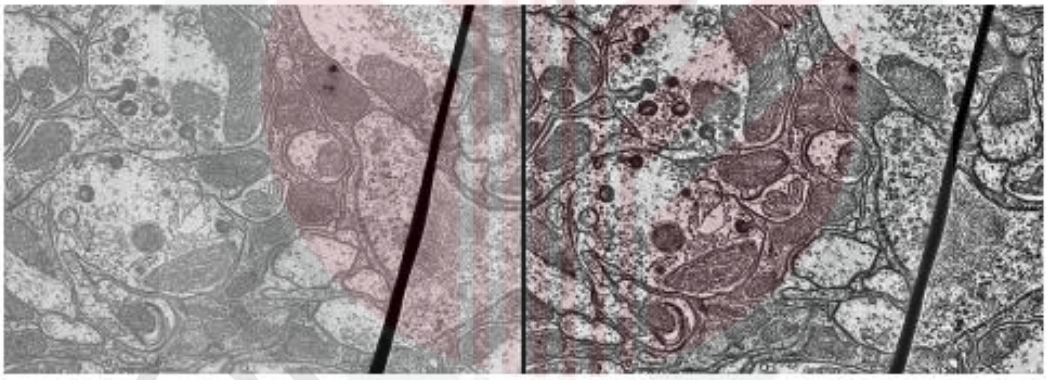


Figure 2.3: An unprocessed electron micrograph (left) has minimal contrast, making feature detection difficult. After running the Contrast-Limited Adaptive Histogram Equalization (CLAHE) plugin in ImageJ, the resulting image (right) is suitable for further analysis. For this image, the following parameters were used: block, 50; bins, 256; max slope, 2.5. (Schindelin, J., Rueden, C. T., Hiner, M. C., & Eliceiri, K. W., 2015)

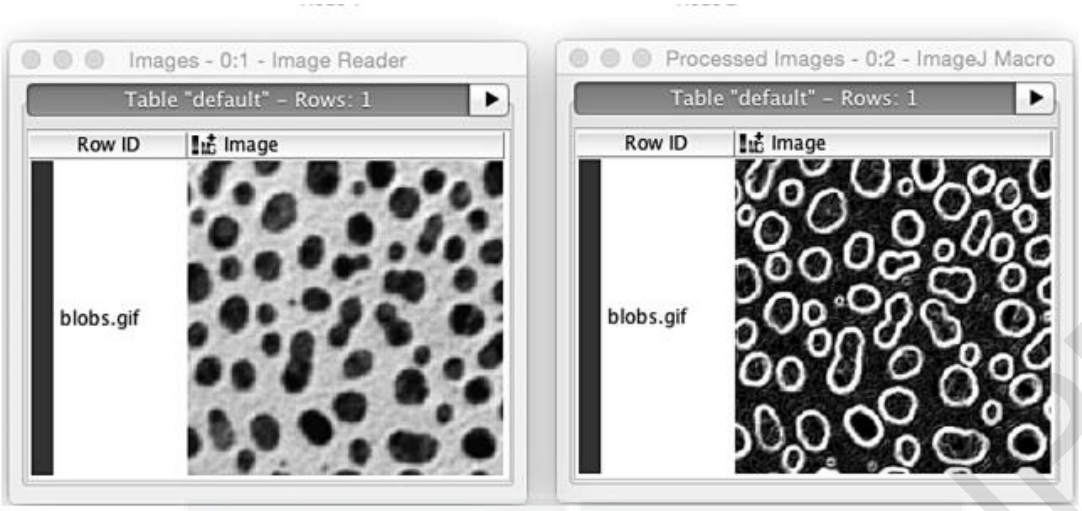


Figure 2.4: ImageJ macro executed in a KNIME workflow. The Find Edges execution shown here, used to identify regions of high contrast, is one of several prepared functions bundled with the ImageJ KNIME node. This node is essentially an ImageJ script editor that is capable of running any ImageJ macro code that is headless-compatible (not requiring a user interface). In this way, users gain access to a significant number of ImageJ functions, coupled with the reproducibility and documentation inherent in KNIME workflows. (Schindelin, J., Rueden, C. T., Hiner, M. C., & Eliceiri, K. W., 2015)

2.4 Thesis based on the Benefits and Effectiveness of Virtual Lab and Video Techniques.

In current technological age, using a video demonstration approach before performing an experiment would bring several advantages for students. Students' has more confidence in handling lab equipment might be boosted by video demonstrations. Students' in beforehand, without video demonstrations, recollection of the experimental demonstration is hampered by the fact that they may have already spent up to three hours in the lab completing an experiment prior to getting the tutorial, leaving them tired, uninspired, and perhaps unmotivated while listening. Aside from that, students would have to stay in class after finishing their experiment for the week to get a walk-through on their next experiment. According to Bradley. Cicciarelli (2013), when two or more student teams finished their experiments at the same time, this was particularly inefficient because it meant that at least one team would have to wait for the instructor to finish giving a tutorial to another group of students before he could give them one.

This section had discussed about the previous work paper on the effectiveness of virtual lab and video lab demonstration. There are quite number of paper that had done a research on effectiveness of online lab using video demonstration.

The effectiveness of virtual experiments in science education has gained considerable popularity in research (Hurtado-Bermúdez & Romero-Abrio, 2020). Virtual Labs have a lot of educational potentials since they allow people to 'learn by doing.' By adjusting the input and watching the effect on the output, students can investigate a number of what-if scenarios. There

have been several past research theses done on online labs.

One of the paper work is the impact of using a virtual laboratory on conceptual understanding and attitudes toward physics students which is done by Faour, M.A. and Ayoubi, Z., (2018). It was studied of the impact of using virtual lab in conceptual understanding of the direct current electric circuit and their attitudes towards physics. This test was used as pre-test and post-test in order to assess students' conceptual understanding and to compare the efficiency of virtual lab and interactive demonstrations using real lab equipment. Utilising computers in science classes is appropriate and convenient, especially when the information is well-used (Tüysüz, 2010). Such visualizations cannot be done using traditional real lab (Perkins et al., 2006). Therefore, the importance of virtual laboratories has lied in its ability to introduce the concepts by referring to the microscopic level in contrast to the real lab that only shows the macroscopic properties (Wieman & Perkins, 2005). Faour, M.A. and Ayoubi, Z. (2018), state that the result shown that the usage of a virtual lab may have encouraged pupils to conduct experiments.

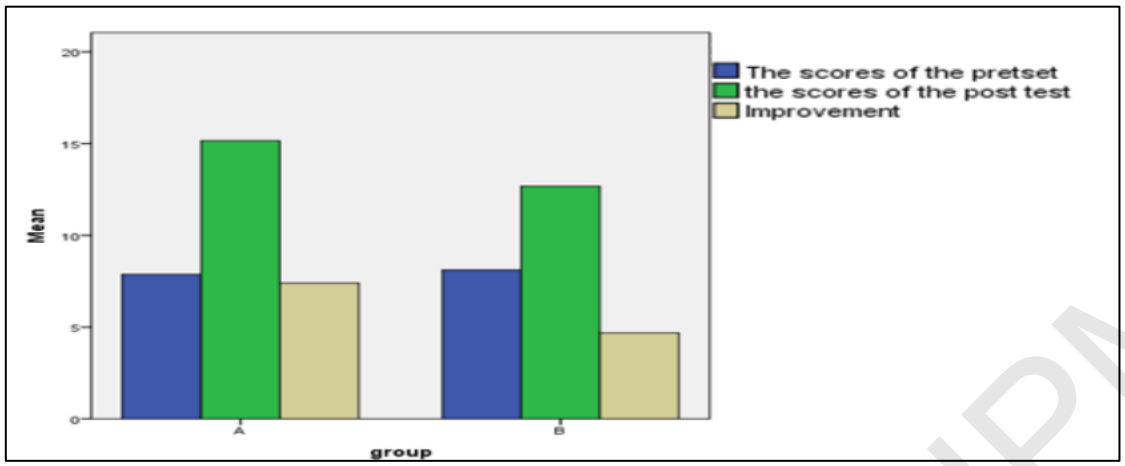


Figure 2.5: Mean scores of pre and post Direct tests. (Faour, M.A. and Ayoubi, Z., 2018)

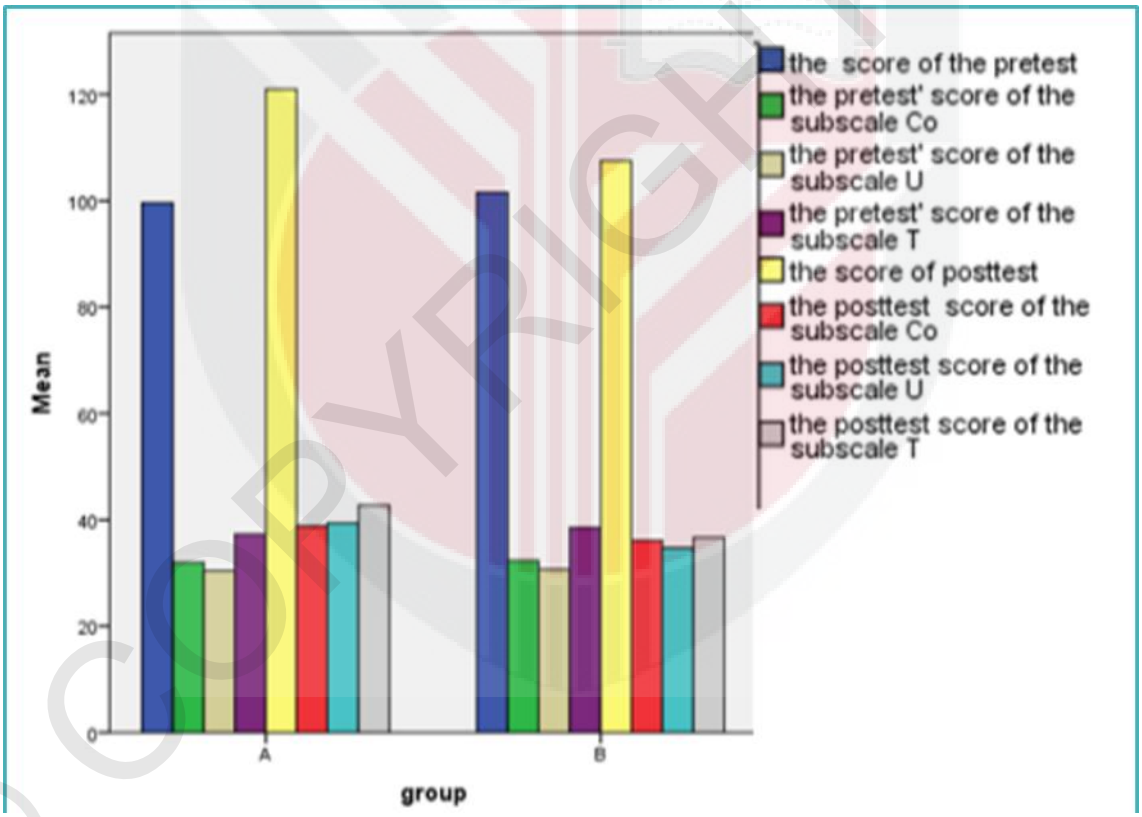


Figure 2.6: Means of the PAS and each subscale scores. (Faour, M.A. and Ayoubi, Z., 2018)

Aronne, Nagle, Styers, Combs and George (2019) had done a research on the impact of video-based pre-lab demonstration on college students' attitudes and achievement. In this research work, the efficiency of two different methods of delivery for pre-laboratory presentations in an undergraduate general chemistry laboratory was compared: a standard lecture versus an in-class video presentation. Students who got their pre-laboratory teaching in a regular lecture vs. an in-class video format were contrasted on laboratory quiz scores and completion times. Videos have long been recognized as an effective source of communication of laboratory skills (Meloan, 1971). In teaching students' manipulative laboratory skills found that videos were superior to written instruction. (Kempa and Palmer, 1974). Students who watch video demonstration when doing pre-laboratory were took less time to perform the experiments themselves. Aronne et. al. (2019) concluded that the mean quiz score for video pre-laboratory is higher compare to lecture pre-laboratory. Video pre-laboratory demonstration is more efficiency compare to pre-laboratory that carried out in traditional way.

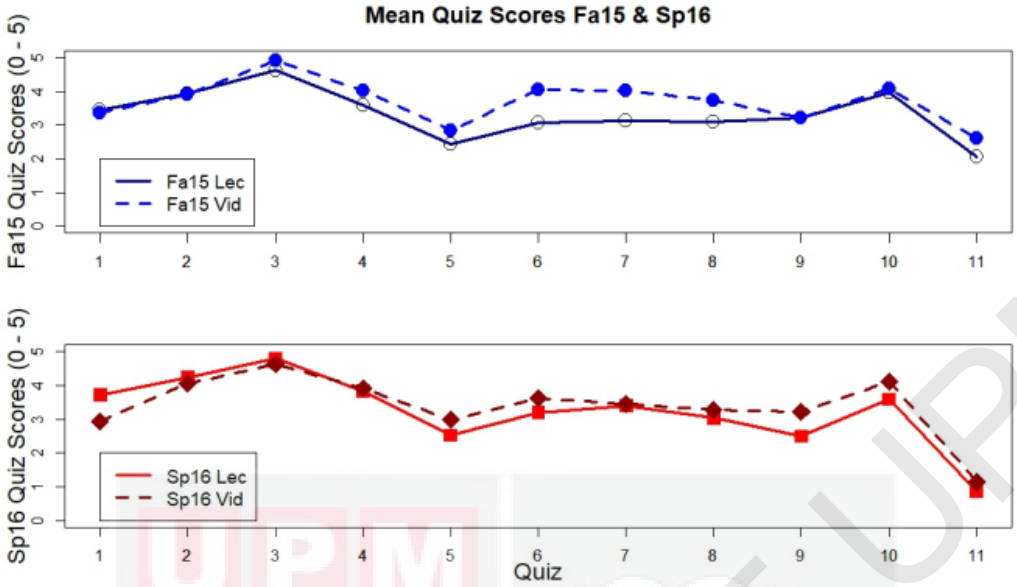


Figure 2.7: Comparison of mean quiz scores for students in the pre-laboratory lecture versus video for fall autumn and spring. (Aronne, Nagle, Styers, Combs and George 2019)

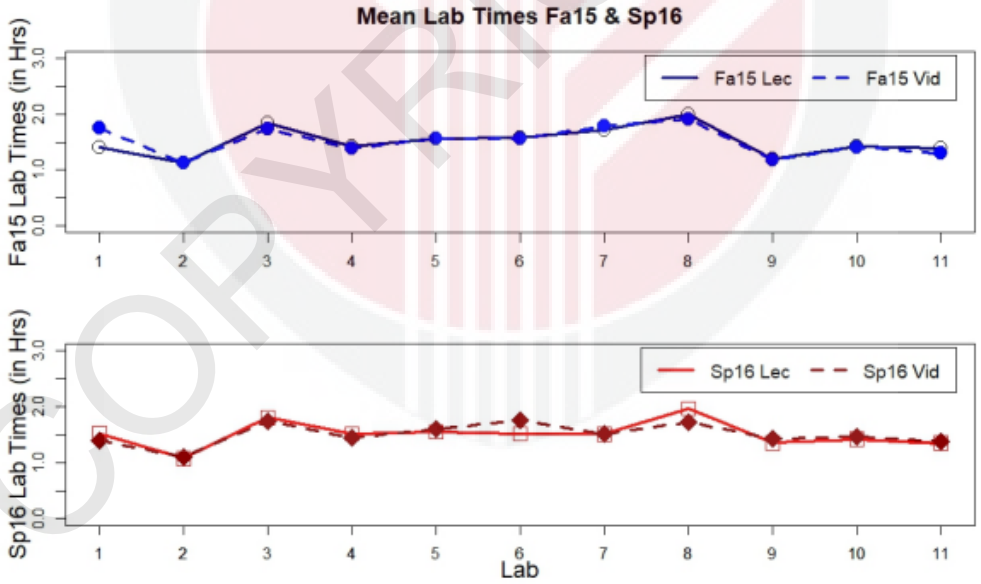


Figure 2.8: Comparison of mean laboratory completion times based on the pre-laboratory lecture versus video for fall autumn and spring.

(Aronne, Nagle, Styers, Combs and George 2019)

Lastly is the feedback based on advantages of video approaches. Bradley. Cicciarelli (2013) had done one research on Use of Pre-Recorded Video Demonstration in Laboratories Courses. Bradley. Cicciarelli (2013) emphasize that one of the advantages that brings to lecturer and students is less time spend in class. For lecturer, they can leave earlier than usual as the lab can finish earlier. Instructor rather than waiting to give another instruction, the instructor might leave after the final experiment is completed. For student, their understanding of the lab experiment was much aided by video techniques. Students can leave class once they have completed their weekly experiment. Additional audio and visual instructions for these experiments should aid students with a variety of learning styles as they prepare for their forthcoming experiment, as well as providing clarification on the location of process lines and equipment in the experimental apparatus (Felder, R.M., and L.K. Silverman, 1998). Bradley. Cicciarelli (2013) also stated that students can watch and playback the video several times in order to get more clearly and understand on the lab experiment. While watching the videos, students can pause, rewind, re-watch, and so on. This is very useful when students are preparing their pre-lab reports.

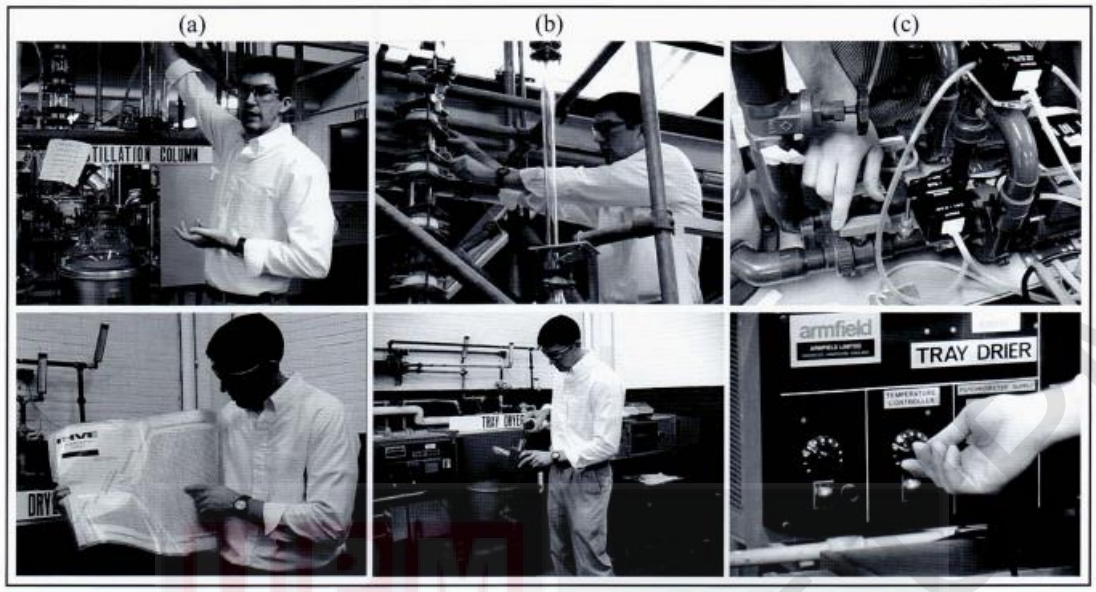


Figure 2.9: Screen-captured images from the video tutorials illustrating (a) introduction and explanation of the experiment, (b) demonstration of experimental techniques, and (c) the location of valves and control knobs used in the experiment. (Bradley. Cicciarelli, 2013)

Most of the student give a feedback that video lab demonstration is more efficiency than the previous method which is giving the pre-laboratory instruction during the class time. Students and lecturer can get more out of their lab time by making pre-recorded video demonstrations of laboratory investigations available to them before they execute the experiments. Given all of the benefits listed above, the videos are well worth the minimal effort required to record and edit them.

CHAPTER 3

METHODOLOGY

3.1 Introduction

A virtual lab is a website or piece of software which is for learning interactively by simulating real-world events. It enables students to investigate a topic by contrasting and comparing several scenarios, to pause and resume the application for reflection and note-taking, and to gain real experimental experience over the Internet. Online laboratories are a great way for students to practice in a safe and online environment. Virtual labs allow students to complete laboratory experiments online and learn the concepts and theories without entering a physical science lab.

In this chapter, the method and process in producing the video lab demonstration will be discussed. The theory of the instrument used in characterize the sample will also be discussed. The instruments used for this thesis paper is ImageJ application, Google Meet application, CapCut application and Likert Scale method.

3.2 Software that used in this thesis

There is some software application that has been used to do this project. The first software used is YouTube. YouTube will be used as a reference channel.

Other than that, the software that was used to experiment is the ImageJ software. Lab experiments for Analytical Methods of Structure and Microstructure will be produced using ImageJ software. It will be recorded in a video form and let students that take this course lab refer to the video. ImageJ software link will be posted below the lab module as students can experiment by themselves.

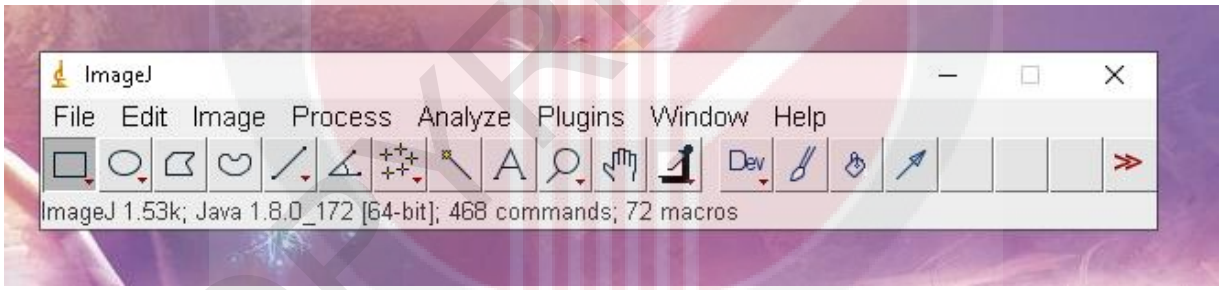


Figure 3.1: ImageJ Software.

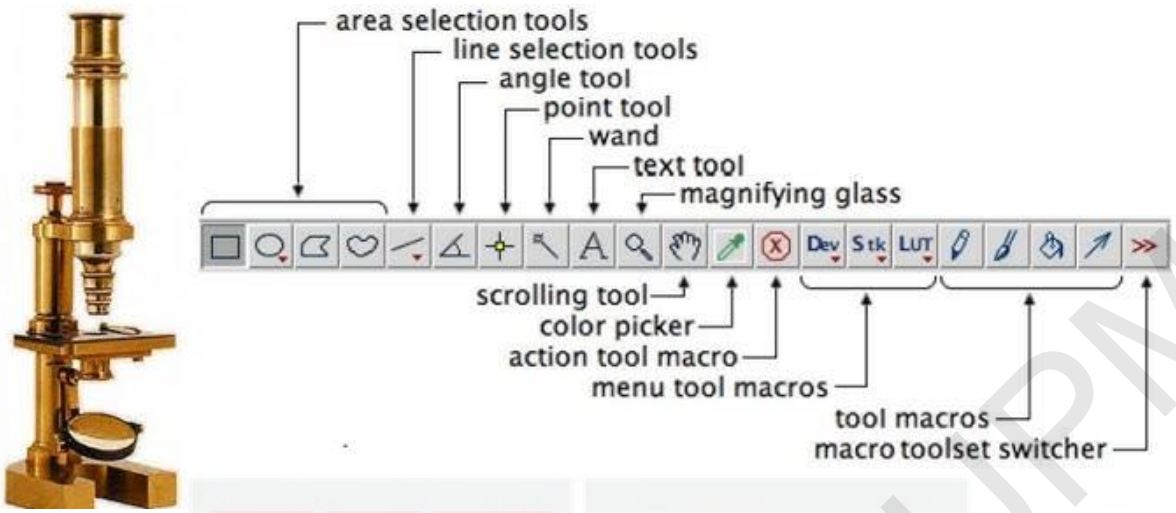


Figure 3.2: The button tools of ImageJ application. (Santanu Mandal, 2017)

Link for ImageJ software: https://imagej.nih.gov/ij/download.html

For recording, the application that been used is Google Meet. It was used to recorded the step on how to used ImageJ application in analyzed structure and microstructure. All the step to use this ImageJ was recorded.

For editing video, an apps called CapCut was used. It was used to edited and combined all the recorded video part together. The script was added into the video, this is to let students be more clearly and understand the video. Background music is added into the video. The video also decorated with some frame around the word. This is to make the video more interesting and interactive for students to watch and learn.

Figure 3.3: Google Meet application

Figure 3.4: CapCut application

Likert Scale is used for measure attidues using rating scales. The Likert scale, in its final form, is a five (or seven) point scale that allows people to express how strongly they agree or disagree with a given proposition. The Likert Scale was used in this survey and it was insert at the google form.

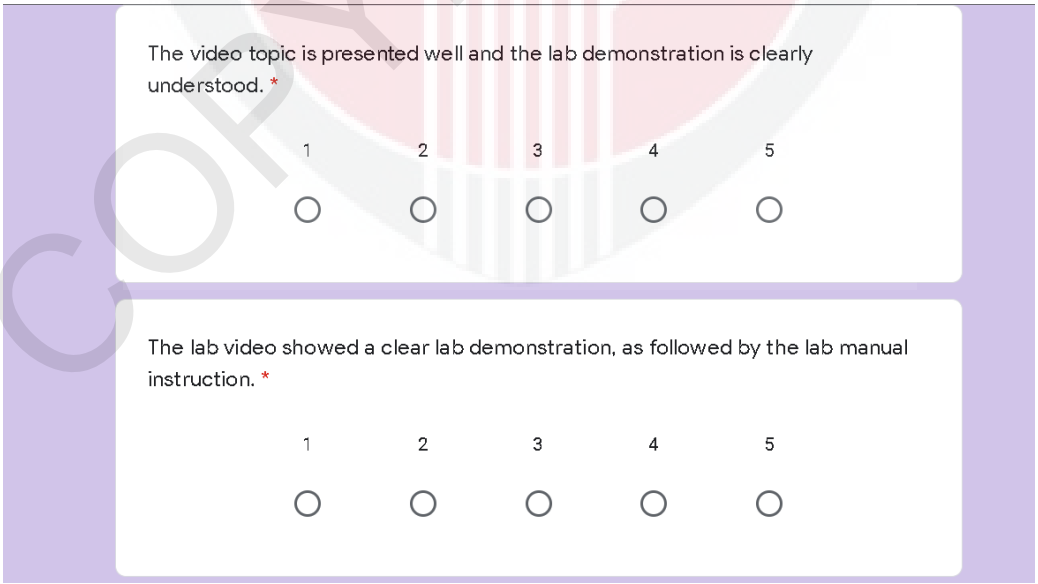


Figure 3.5: The picture of the Likert Scale that insert in google form.

3.3 Lab Module of the Experiment

According to the video recorded that been produced, there are 5 part for this experiment. For this part of the lab module of analysis of structural by ImageJ will be provided below.

At the end of this activity, students will be able to:

1. Measure the size of the particle.
2. Calculate the d-spacing (interplanar spacing) of the particle.
3. Calculate hkl plane value of the particle.
4. Determine the crystal structure of the particle.

Part 1: Software Installation

1. First of all, download the software link of ImageJ via the link given below:

   https://imagej.nih.gov/ij/download.html

2. Install ImageJ on your computer. It will show a program like the figure shown below.

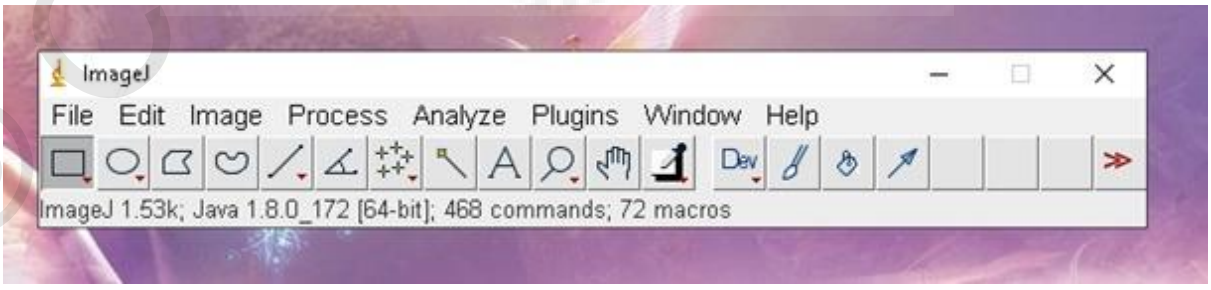


Figure 3.6: ImageJ Software.

Part 2: Ways to find the Size of Particle

1. Open ImageJ, click File >> Open. Choose the image of the sample.

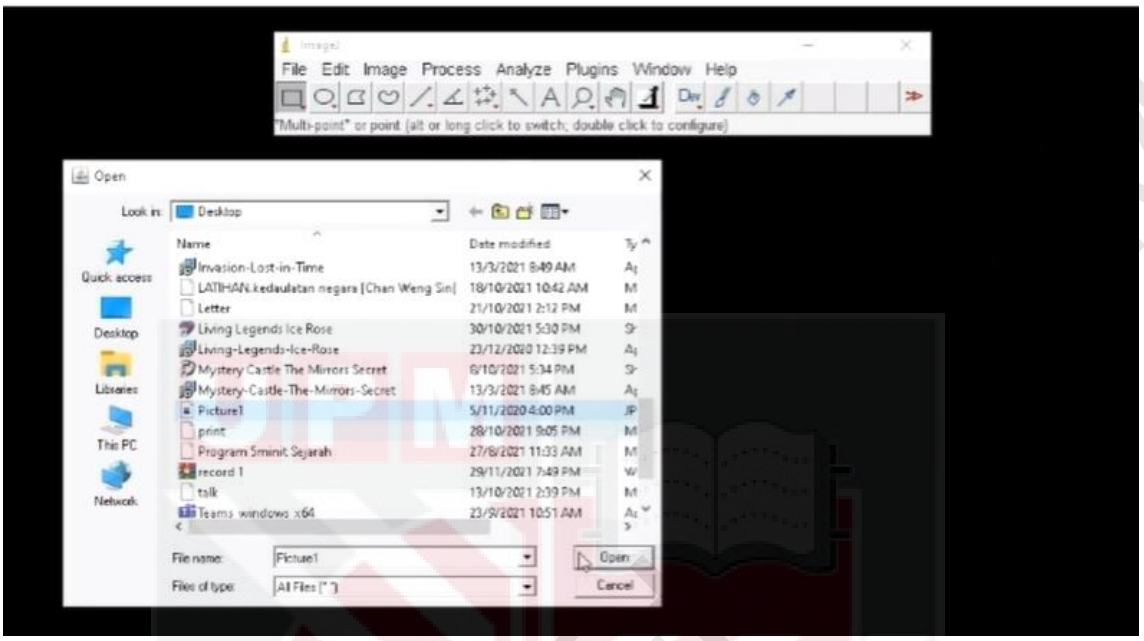


Figure 3.7: Choose the image that need to calibrate in this experiment.

2. Next step is to calibrate the image. To start the calibration, magnify the image at scale bar.

3. Click the Straight line tool button. Draw a straight line at the scale bar.

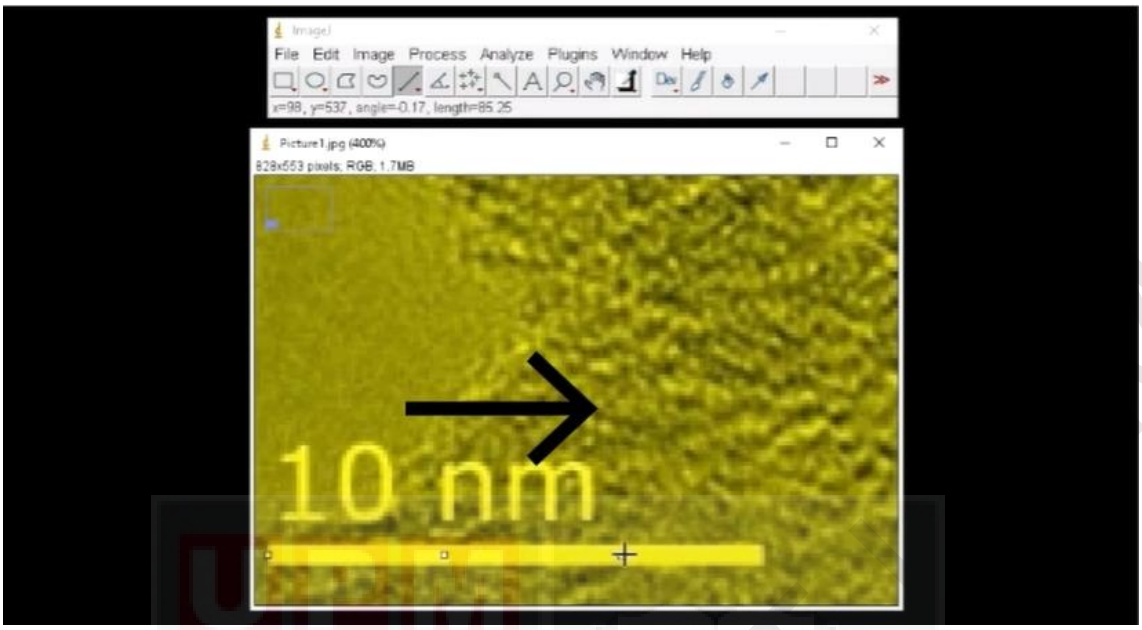


Figure 3.8: Draw a line on the scale bar.

4. Go to Analyze >> Set Scale then the Set Scale window will pop up.
5. Change the Known distance and Unit of Length with the same value as the image.
6. And then, you can measure the size of the particle. Choose one of the particle that you want to measured.
7. Click the Straight button on the particle image >> Analyze >> Measure.
8. From the results box, you will get the size of the particle.

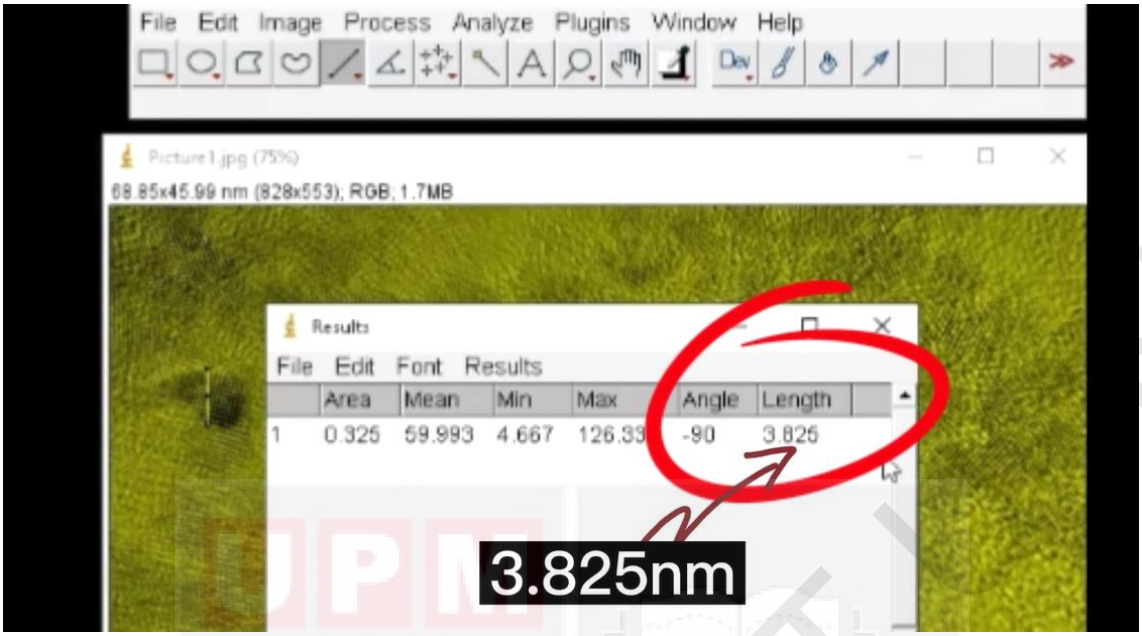


Figure 3.9: The result box that show the size of the particle that been measured.

Part 3: Step on getting the Diffraction Pattern

1. Crop the specific image particle by clicking the Rectangle tool button.
2. After draw rectangle on the particular part, click Image >> Crop.
3. After that, you need to form the Fast Fourier Transform (FFT). Click Process >> FFT >> FFT. From the FFT image, you will get the diffraction pattern.

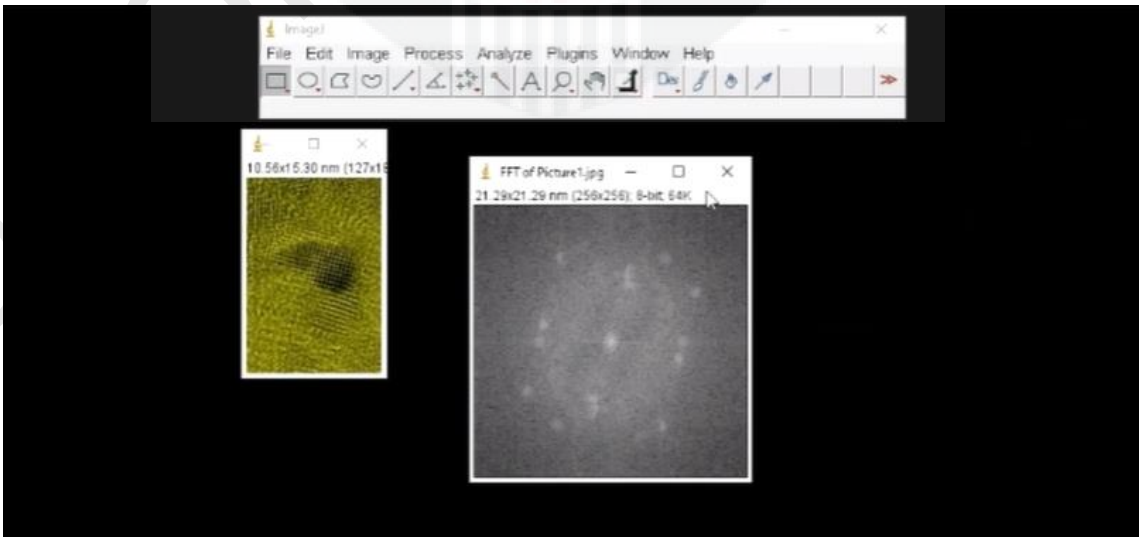


Figure 3.10: The diffraction pattern that get from the FFT image.

4. You need to find at least 3 bright dots that parallel to each other from the center.
5. Choose the brightest dot (not center) and fill it. Click the Oval tool button and draw an oval on the brightest dot. Click Edit >> Fill.
6. Find the inverse FFT image by clicking Process >> FFT >> Inverse FFT. You will get an inverse FFT image.
7. You need to adjust the brightness of the image to get a clear fringes image. Click Image >> Adjust >> Brightness/Contrast >> Auto >> Apply.

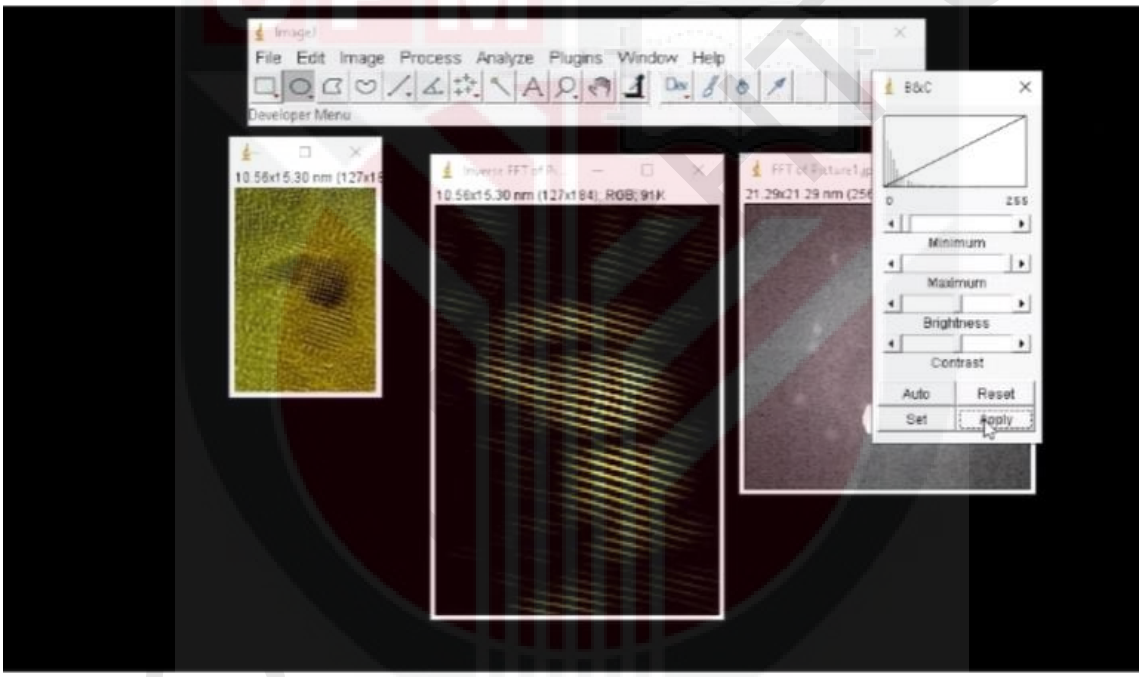


Figure 3.11: The Fringes image get from inverse FFT image.

8. From the inverse FFT image, you need to rotate the image until the lattice fringe in horizontal or vertical line.
9. Click Image >> Transform >> Rotate >> Change Angle>> Preview. Adjust the angle until the fringes parallel to the vertical yellow line. After that press OK.

Part 4: Step to get d-spacing measurement

1. After you get straight line fringes, you need to magnify the image and measure the pixel (bright to bright).
2. Click Zoom, magnify to the maximum until see the pixel clearly.
3. Draw Straight line from bright pixel to bright pixel >> Analyze >> Measure.

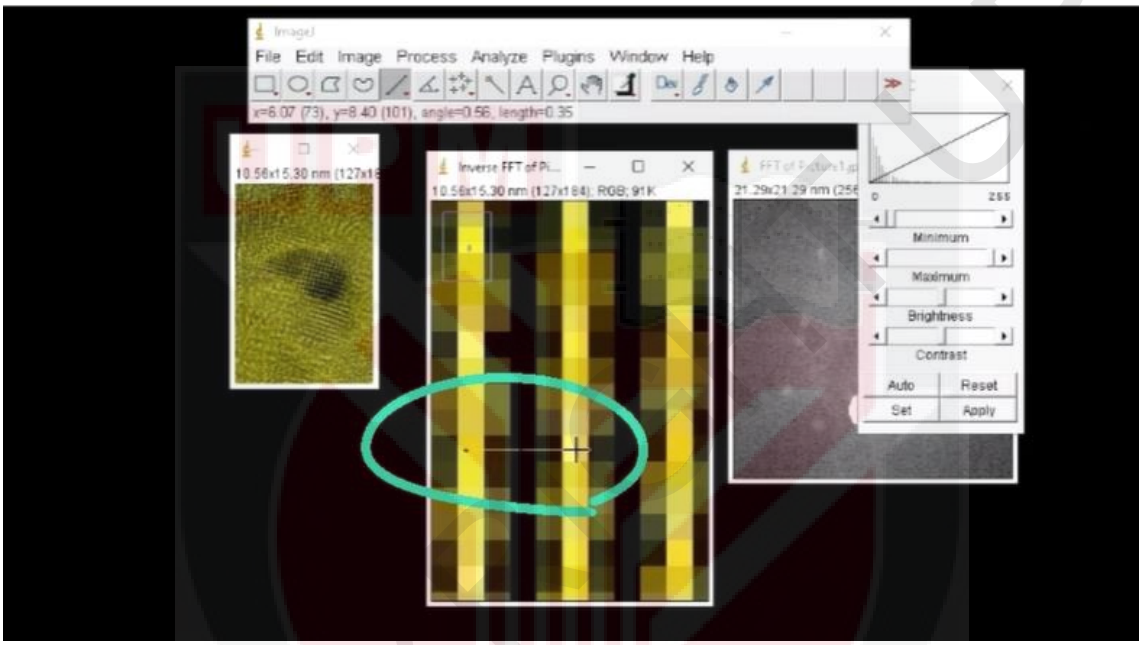


Figure 3.12: Draw a straight line on the fridge from bright pixel to another bright pixel.

4. From the results box, you will get d-spacing of the particle by looking at Length.

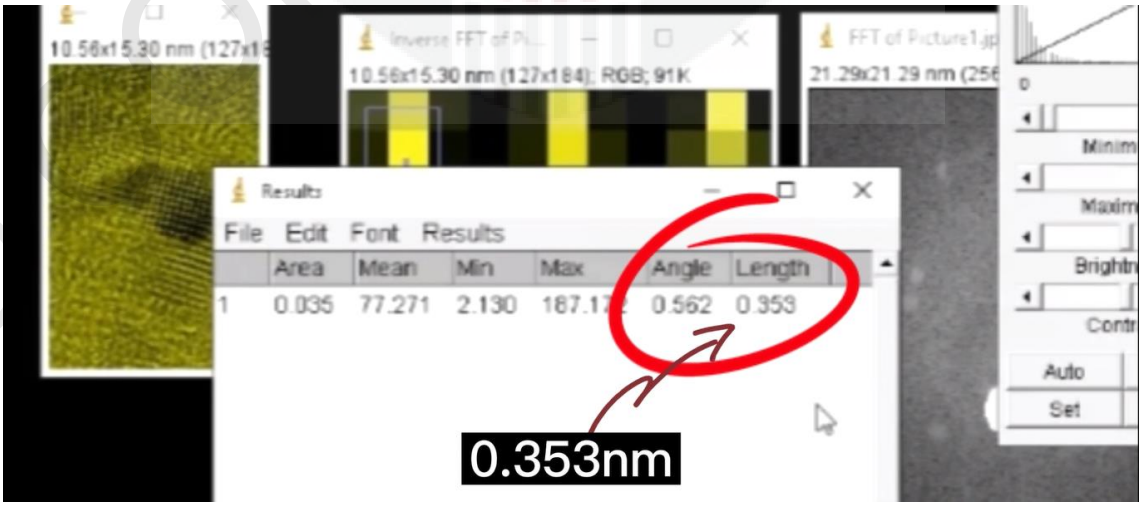


Figure 3.13: The d-spacing value for the image particle.

5. Choose 5 different spots and repeat the steps from Part 2 to 4 to get more accurate answer.

6. After that record the d-spacing value in table form shown below.

Table 1

SPOT	d-spacing	(h k l)
1		
2		
3		
4		
5		

Table 3.1: Table for recorded and calculate the value of d-spacing and hkl value.

3.4 Flow of Preparing the Online Lab

Some steps need to be done while preparing the online lab. Firstly, research is done by referring to previous thesis work. It is to investigate the way on how to construct an understandable laboratory video so that students can complete their lab work more easily. The lab module was written in this thesis. After that, the demonstration video with the result was prepared. The step of the experiment using ImageJ software was recorded. It was recorded using Google Meet application. The recorded video is then edited using CapCut application. Students can study the lab module and watch the video to understand the lab experiment. Lastly, the survey research for online lab on student feeling will be done using google form.

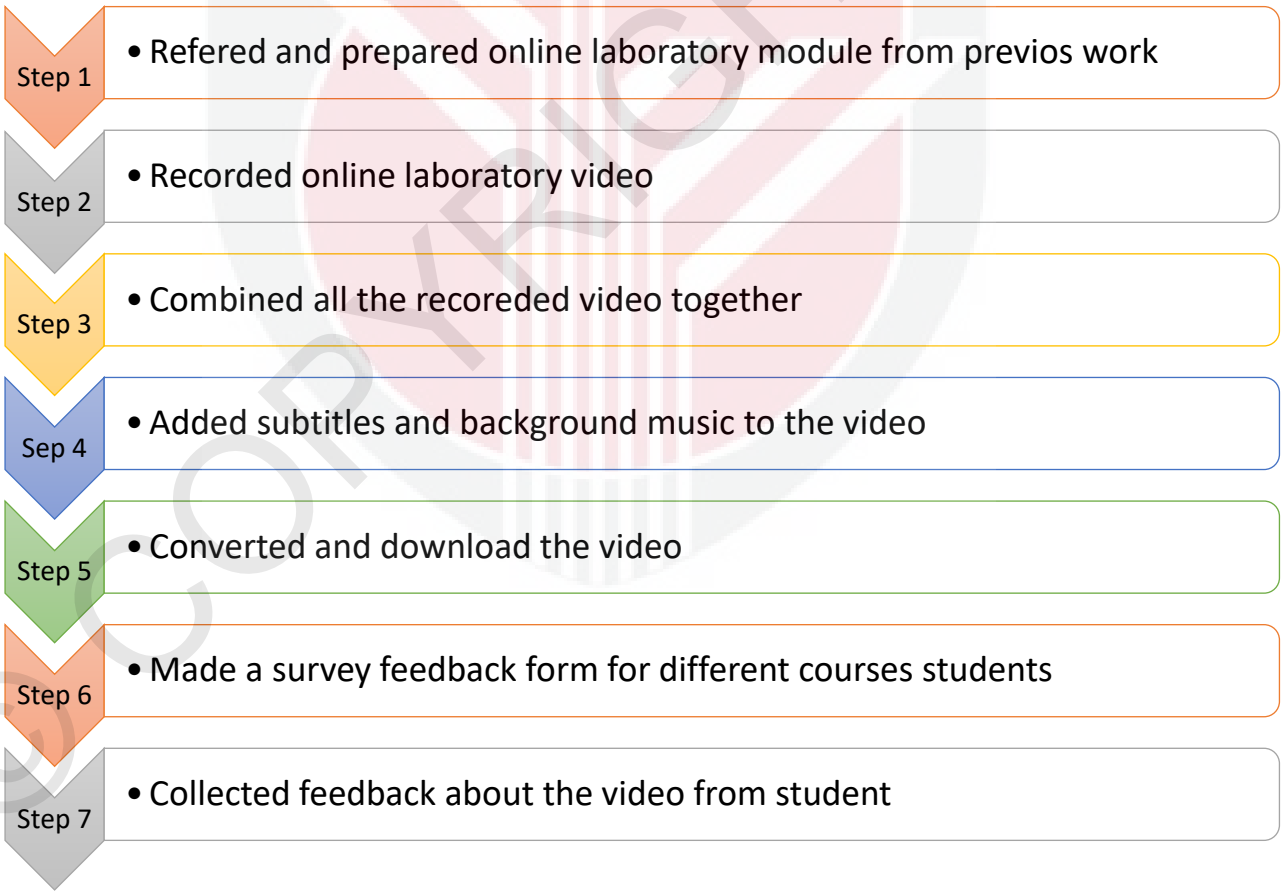


Figure 3.14: Flowchart of Preparing the Video Demonstration for Online Lab.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter focused on the outcomes obtained from the students' feedback. The findings were explored in terms of whether students prefer face-to-face or online learning. Aside from that, students' feedback on the virtual laboratory video will be examined to see if they comprehended the recorded video demonstration.

4.2 Demographic Information

The demographic features of the respondents, in general, are discussed in this section. The gender, courses, and current semester of the responders are also included. There are a total of 30 students from various courses who have responded to this report's feedback. In this report, both male and female students participated, as shown in Table 4.1.

Table 4.1: Male Students and Female Students that participate in this report.

	Male	**Female**
Percentage (%)	26.7	73.3
Total	8	22

Almost all of the respondents are from Material Science courses (60%) concerning in Figure 4.1. This is followed by Others courses (26.7%) and Major Physics course (6.7%). For Science Instrumentation courses and Physics in Education had the same data which is (3.3%) respectively.

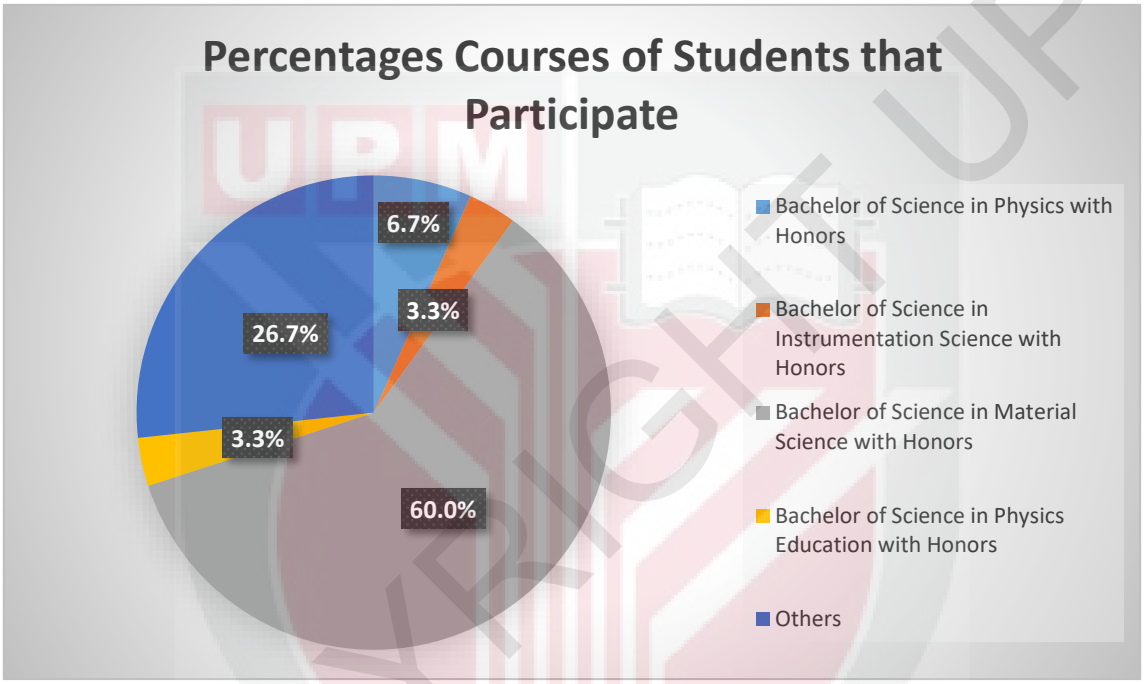


Figure 4.1: Percentage Courses of Students that participate in this report.

Semester 5 (26%) and semester 7 (73.3%) had the most respondents in this study. This is due to this course being only offered in semester 4 and that the majority of responders had already taken it. 53.3% of students have taken this course before, while 46.7% of students have not taken this subject.

4.3 Survey on Students Responds Toward Online Class and Online Lab Learning

According to the data collected, students like to have virtual class learning compared to face-to-face learning. It takes 53.3% of the students who like virtual classes compared to 46.7% of students that like to have face-to-face classes.

Table 4.2: Type of class learning that students prefer.

	Virtual Class Learning	**Face-to-Face Learning**
Percentage (%)	53.3	46.7
Total	16	14

From students' feedback, online classes have both advantages and disadvantages. The majority of students agree that having an online class is beneficial and convenient. It is effective in the current covid-19 pandemic. The online lesson is effective, efficient, and has enhanced mental well-being. Virtual learning provides a wide range of educational opportunities for both students and instructors, with the most important benefit being the ability for students to enroll in a class at any time that is convenient for them (Koller, Harvey, & Magnotta, n.d.). Students, on the other hand, believe that two-way communication is difficult to achieve. Some of them believe that physical education will be required in the future due to new students' lack of understanding and experience. They can only concentrate during the first few minutes of class, after which they begin to lose interest. The online class is both challenging in terms of handing in the assignment and harder to ask questions to lecturers or teachers, but at the same time, it is relaxing because can have our class at home and with everything within our reach.

Figure 4.2 shows how students think about virtual class learning/ virtual lab demonstration. There are five (5) options that allow the flexibility in online learning, which are: affordable alternative from physical class/ lab, Online class/ lab can provide a visual aid to improve understanding and learning, an online class/ lab can ensure students' safety, especially during the pandemic time and all above.

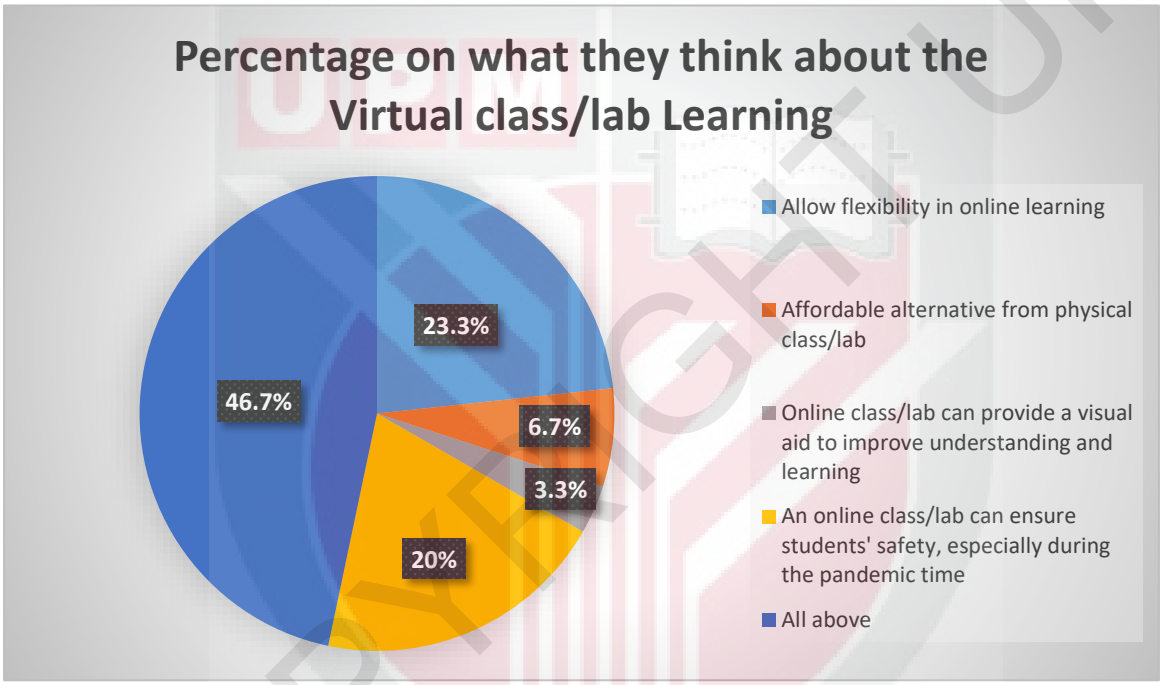


Figure 4.2: Percentage of what Students think about Virtual Class Learning or Virtual Lab Demonstration.

During the Covid-19 pandemic, students more preferred having virtual lab (53.3%) more than face-to-face lab (46.7%). The data get from this section is the same as in Table 4.2. This is because there are numerous benefits to having an online laboratory in a pandemic crisis. One of the most significant advantages is that we can all avoid Covid-19 infections. This is because we can avoid coming into contact with persons who are unaware that covid-19 is there. Aside

from it being a safer option in our trying times of the pandemic period, it is also convenient for us to be able to pause the video if we ever got lost during the demonstration. In short, being able to replay the video at any time also one of the advantage for having online lab using video. Bradley. Cicciarelli (2013) emphasize that while watching the videos at their leisure, students can pause, rewind, re-watch, and so on. This will come in handy as they compose their pre-lab reports. Besides that, students think that it would be more understanding and can get hands-on experience in handling experiments.

Although the percentage of students who like to have an online lab is higher than a physical lab, students still think that a physical lab can gain more experience in doing the lab. 93.3% of students agree on physical lab gain more experience while 6.7% of students think that online lab gains more lab experience. Even if the majority of students understand the video demonstration offered in this thesis, they still believe that understanding the lab demonstration using an online lab (80%) is more difficult than understanding the lab demonstration utilizing a physical lab (20%). Apart from that, students think that video demonstration is the best method of doing an online lab. 66.7% which is 20 students think that video demonstration is the best method whereas 33.3% which are 10 students think that online live demonstration is the best method of doing an online lab.

Table 4.3: Lab that will gain more experience in experimenting.

	Physical Lab	**Online Lab**
Percentage (%)	93.3	6.7
Total	28	2

Table 4.4: Lab that is harder to understand the demonstration.

	Physical Lab	**Online Lab**
Percentage (%)	20.0	80.0
Total	6	24

Table 4.5: The best method of doing an Online Lab.

	Video Demonstration	**Online Live Demonstration**
Percentage (%)	66.7	33.3
Total	20	10

Other than that, this survey also took the opinion from students about what they think is the best for a video lab demonstration. Figure 4.3 shows the data get from the students.

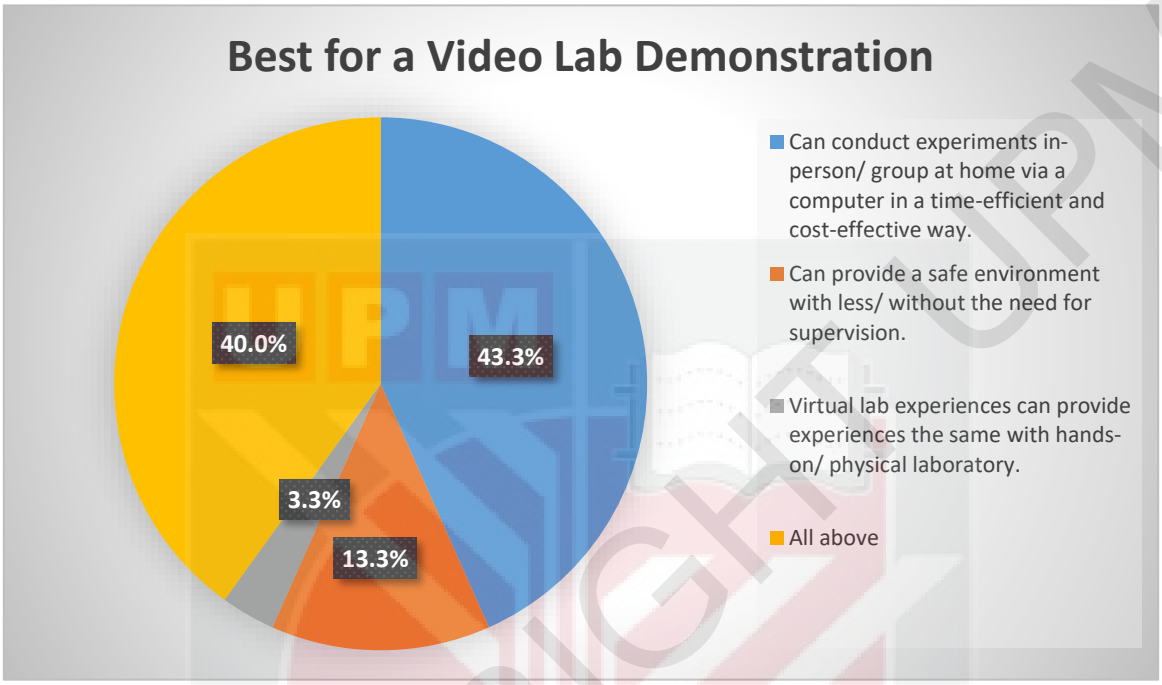


Figure 4.3: Best for a Video Lab Demonstration from students' feedback.

4.4 Evaluation of Respondents' Perception about the Video Lab Demonstration

This segment analyses the results of a survey that was conducted after respondents watched the video lab demonstration. This will document how the movie conveyed information to students and how they reacted to the demonstration film.

4.4.1 Survey on How is the Video after Watching it.

There are 9 questions for this section. Above 50%, which is more than half of the total students, gave a rating of 5 for the video. 16 students (53.3%) thought that the video topic is presented well and the lab demonstration is clearly understood. 17 of them (56.7%) agree that the lab video showed a clear lab demonstration, as followed by the lab manual instruction. 16 of them (53.3%) be under the impression that the lab demonstration video is good and interactive. 56.7% which is 17 students considered that the video has good visuals and used good camera angles whereas 63.3% which is 19 students considered that the video has good sound and has a clear sound. 18 of them (60.0%) said that the video has a clear script was written and a dialogue lines presentation. 17 students (56.7%) found out the lab is easy to do after watching the video lab demonstration and the ImageJ software is easy to access after watching the video. Lastly, 18 students (60.0%) found that this video can be used in online laboratory classes wisely and is very useful to students.

4.4.2 Feedback on How Student feels towards the Video Lab Demonstration.

The majority of the respondents are rated 5 which is satisfied with the ImageJ video lab demonstration. Most of them feel satisfied along with the video being interesting to learn and easy to understand. They also found out that the online lab is more interesting after watching the video lab demonstration. This is due to the video being short and can keep students engaged which can help them to understand well the experiment topic.

Figure 4.4 showed there are more than 70% of the respondent rated 5 for the demonstration video. 76.7% admitted that they can watch and repeat to watch the video anytime when they needed. About 83.3% stated that they can watch the video and do laboratory tasks in flexible time. 73.3% of the respondent said that they can watch the video and do the laboratory task with less supervision from the lab instructor.

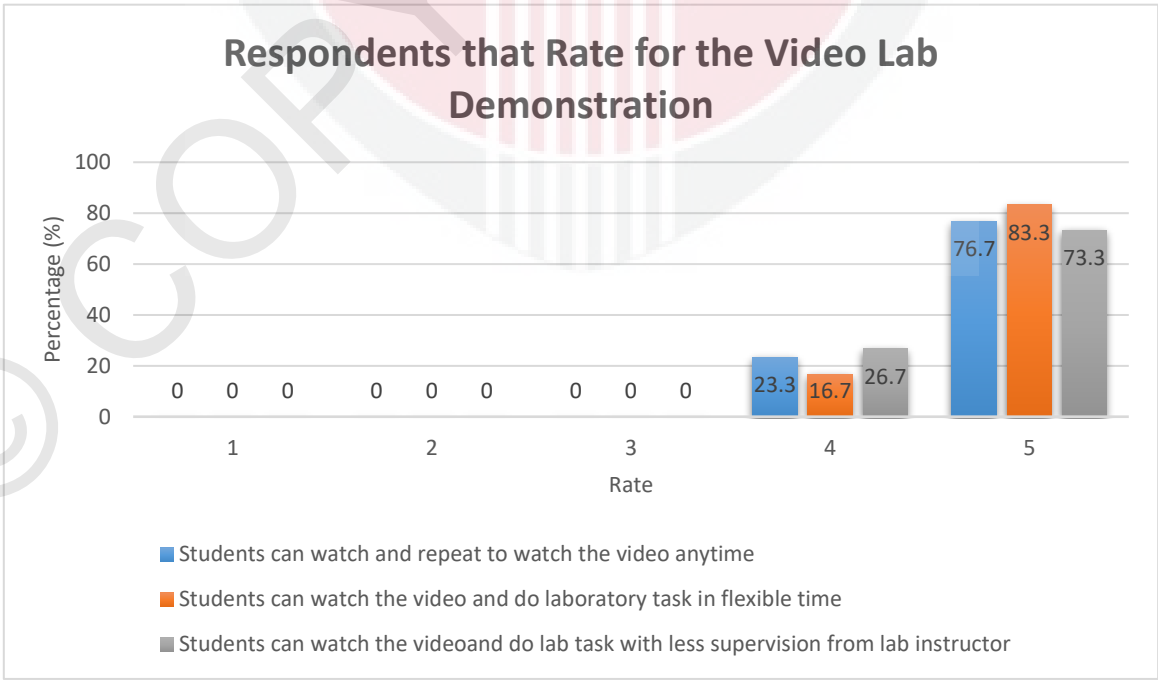


Figure 4.4: Respondents that rate for the video lab demonstration.

Even though the video lab demonstration brings many benefits to students on learning, it still has disadvantages for students. In general, respondents think that the online lab is more challenging compared to the hands-on or face-to-face lab. Figure 4.5 shows students' responses toward this inquiry.

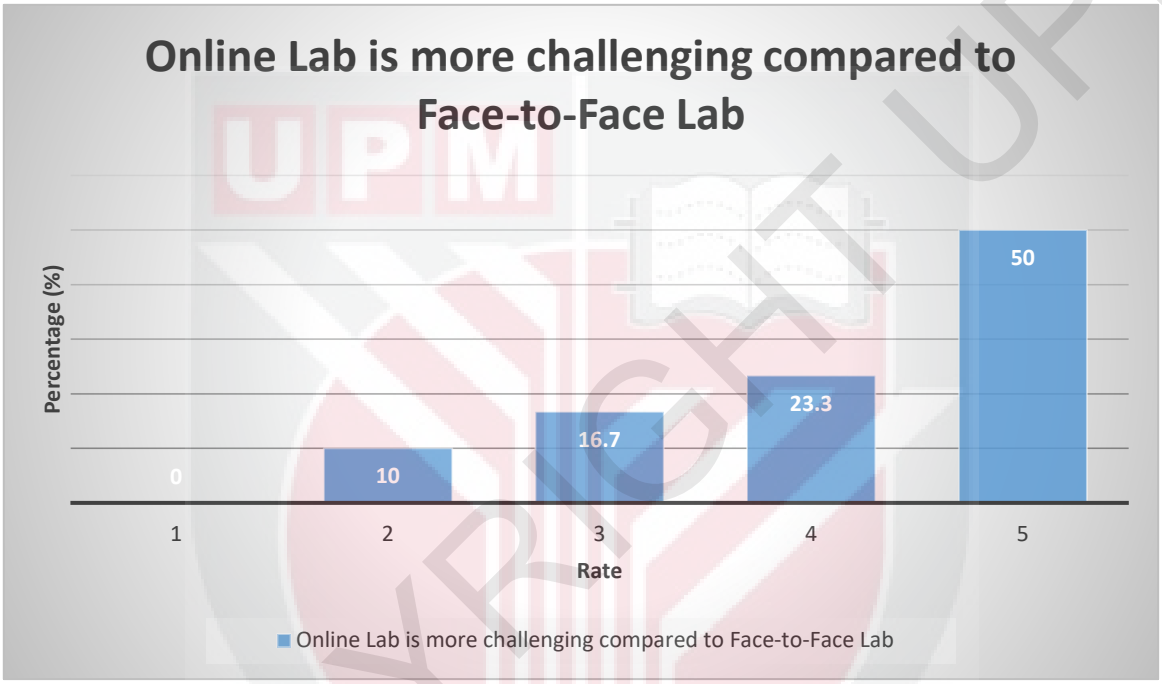


Figure 4.5: Respondent that rate whether online is more challenging compared to hands on or face-to-face lab.

A variety of factors can contribute to a lack of student motivation to succeed in virtual learning. It may arise as a result of students' repeated failures in hardware or software. Students who aren't familiar with technology may see their virtual programs as a technological burden, especially if they need substantial technological manipulation (Luka Ngoyi, 2013). When this happens, technology becomes an impediment rather than an enabler, as it slows down the learning process and irritates students who have insufficient technological knowledge. Lack of

motivation, lack of academic confidence, and lack of technical trust are all challenges to students when building and implementing virtual learning environments. Howland and Moore (2002) investigated the experiences of online distance learners, they discovered that the students lacked confidence in their ability to figure out the requirements of the assignments and that they needed to be guided verbally, indicating that there was a lack of instructor immediacy.

However, the lab video demonstration is still very useful and helps students a lot to complete the lab assignment of the course. This is due to students will more eager to learn and discover a new concept of the topic. They also feel attracted to video-based learning such as hands-on learning based on technology.

4.5 Image Requirement for ImageJ Software.

ImageJ allows multiple images to be displayed on the screen at one time. ImageJ supports 8-bit, 16-bit, and 32-bit (real) grayscale images and 8-bit and 32-bit color images. 8-bit images are represented using unsigned integers in the range 0 to 255. 16-bit images use unsigned integers (0 to 65,535) and 32-bit grayscale images use floating-point numbers. 16-bit and 32-bit grayscale images are not directly displayable on computer monitors, which typically can show only 256 shades of gray. Therefore, the data are mapped to 8-bits by windowing. The window defines the range of gray values that are displayed: values below the window are made black, while values above the window are white.

The File>Open command opens TIFF, GIF, JPEG, PNG, DICOM, BMP, PGM and FITS images. It also opens lookup tables and selections. In addition, files can be saved in TIFF, GIF, JPEG, PNG, PGM, FITS, tab-delimited text, and raw formats. The type of image that used in this lab work is a JPG file image. Ultimately, JPG images and JPEG images are the same things. The only difference between the two file formats is that one comes with one less letter than the other.

ImageJ plugins are designed for the analysis of images and diffraction patterns taken on a Transmission Electron Microscope (TEM). Besides TEM images, ImageJ also can use high-resolution transmission electron microscopy (HRTEM) images for analysis in the diffraction pattern. The image that is used for this analysis is the HRTEM image. This analysis paper used

the HRTEM image for PbS. TEM is a technique that uses the interaction of energetic electrons with the sample and provides morphological, compositional, and crystallographic information. The HRTEM uses both the transmitted and the scattered beams to create an interference image.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, the online laboratory for PHY4204 was successfully completed through video presentation. The results of a survey on feedback data were successfully collected in order to determine the effectiveness of the video laboratory and its benefits provides to students. The majority of students easily comprehend the video and agree that video lab demonstrations can help them during this pandemic.

As a result of the findings, students discovered that online lab demonstrations using video have both benefits and drawbacks. One of the advantages that the majority of students agree on is that an online laboratory is more beneficial and convenient than a traditional laboratory. In the current covid-19 pandemic condition, it is effective. The online course was productive, efficient, and beneficial to one's mental health. Aside from being a safer option during these difficult epidemic times, being able to pause the video if get lost throughout the demonstration is also beneficial. In a nutshell, the ability to repeat and replay the video at any time. Apart from that, students believe it will enhance their learning and provide them with practical experience with

experiments. However, some students believe that using an online laboratory will hinder their learning. One disadvantage is that it could be caused by students' recurrent hardware or software failures. Students who aren't expert with technology may view their virtual programmes as a technological burden, especially if they demand a lot of technological manipulation. This could slow down the learning process and irritate students who do not grasp technology. Other than that, students also face problems such as a lack of motivation, academic confidence, and technical trust while creating and implementing virtual learning environments.

Despite the fact that face-to-face experiments provide more laboratory experience than online experiments, more than half of students believe lab video demos are still very beneficial in completing the course's lab assignment. The majority of them can understand what is being said in the video, and the instructions are straightforward.

5.2 Recommendation for Future Work.

Although students showed satisfaction though the video lab demonstration, there is still room for improvement in the video created. Therefore, there are a few recommendations suggested which arises from this research results:

1. One of the improvement needed is turning down the volume of the background music. Loud background music tends to be a distraction in the video and would divert the student's attention from the content of the video.
2. The video can be improvising it by improving the intonation to making the video more fun to be learn.
3. Assign an ampoule time to each stage (for example, a minute or two) so that students can better comprehend each step.

REFERENCES

Abramoff, M.D., Magalhaes, P.J., Ram, S.J, (2004). "Image Processing with ImageJ". *Biophotonics International, vol. 11,* no. 7, pp. 36-42.

Al Rawashdeh, A. Z., et al., (2021). Advantages and Disadvantages of Using e-Learning in University Education: Analyzing Students' Perspectives. *The Electronic Journal of e-Learning, 19*(2), pp. 107-117.

Andersson, A., (2008). Seven Major Challenges for e-learning in Developing Countries: Case Study eBIT, Sri Lanka, International *Journal of Education and Development using ICT, Vol 4*, Issue 3.

Aronne, Nagle, Styers, Combs & George (2019). The Effects of Video-Based Pre-Lab Instruction on College Students' Attitudes and Achievement in the Digital Era. *Electronic Journal of Science Education, Vol. 23*(5), 3-21.

Barbour, M. K., & Reeves, T. C. (2009). The reality of virtual schools: A review of the literature. *Computers & Education, 52*(2), pg 402-416.

Bart J. Van Zeghbroeck, (1997). Bravais lattices. Retrieved from https://ecee.colorado.edu/~bart/book/bravais.htm

Bradley. Cicciarelli (2013). Use of Pre-Recorded Video Demonstrations in Laboratory Courses. *Chemical Engineering Education, 47*(2), 133-136.

Brindley, J., Blaschke, L., & Walti, C. (2009). Creating effective collaborative learning groups in an online environment. The International Review of Research in Open and Distance Learning. Retrieved from: http://www.irrodl.org/index.php/irrodl/article/view/675/1271

BYJU'S (2022). What is Unit Cell. Retrieved from https://byjus.com/chemistry/bcc-fcc-primitive-cubic-unit-cell/

Carnevale, D. (2001). Assessment takes center stage in online learning. *Chronicle of Higher Education, 47*(31), 43-45.

Castleman K. (1996). Digital Image Processing. Upper Saddle River 1-667.

Clothey, R. (2008). Education for everyone: Expanding opportunities through distance education. *Journal of the World Universities Forum,* 1(4), 81-87.

Cresswell, Sarah L.; Loughlin, Wendy A.; Coster, Mark J.; Green, David M. (2019). *Development and Production of Interactive Videos for Teaching Chemical Techniques during Laboratory Sessions*. *Journal of Chemical Education, (), acs.jchemed.8b00647–*.

Dr. Saul McLeod, (2008). What is Likert Scale? Retrieved from https://www.simplypsychology.org/likert-scale.html

Eliceiri KW, Berthold MR, Goldberg IG, Ibanez L, Manjunath BS, Martone ME, Murphy RF, Peng H, Plant AL, Roysam B, Stuurman N, Swedlow J, Tomancak P, Carpenter AE. (2012). Biological imaging software tools. *Nat Methods, 9*(1), 697-710.

Erik McKee, Vickie M. Williamson, Laura E. Ruebush, (2007). Effects of a Demonstration Laboratory on Student Learning. *Journal Science Education Technology, 16*(1), 395-400.

Faour, M.A. & Ayoubi, Z. (2018). The effect of using virtual laboratory on grade 10 students' conceptual understanding and their attitudes towards physics. *Journal of Education in Science, Environment and Health (JESEH), 4*(1), 54-68.

Farrell, G. M. (1999). The development of virtual education: A global perspective. A study of current trends in the virtual delivery of education. The Commonwealth of Learning, Vancouver, Canada. Retrieved from http://dspace.col.org/bitstream/123456789/215/1/The-Development-Virtual-Ed-Global.pdf

Felder, R.M., & Brent, R. (2005). Understanding student differences. *Journal of Engineering Education,* 94(1), 57-72.

Felder, R.M , and L.K. Silverman, (1998) "Learning and Teaching Styles in Engineering Education," Engr. Education , 78(7), 674.

Graf, S., Kinshuk, & Liu, T. C. (2009). Supporting teachers in identifying students' learning styles in learning management systems: An automatic student modelling approach. *Educational Technology & Society,* 12(4), 3-14.

Hook, J.R.; Hall, H.E. (2010).*Solid State Physics*. Manchester Physics Series (2nd ed.). John Wiley & Sons.

Howland, J. L., & Moore, J. L. (2002). Student perceptions as distance learners in Internet-based courses. *Distance Education, 23*(2), 83-195.

Hurtado-Bermúdez, S., & Romero-Abrio, A. (2020). The effects of combining virtual laboratory and advanced technology research laboratory on university students'

conceptual understanding of electron microscopy. *Interactive Learning Environments.*

JiĜí Zounek & Petr Sudický, (2012). Heads in the Cloud: Pros and Cons of Online Learning. Publication E-learning: Learning with online technologies

Karen Croker, Holger Andersson, David Lush, Rob Prince & Stephen Gomez (2010) Enhancing the student experience of laboratory practical through digital video guides. *Bioscience Education, 16*(1), 1-13.

Kelsey Miller, (2019). The Benefits of Online Learning: 7 Advantages of Online Degrees. Retrieved from https://www.northeastern.edu/graduate/blog/benefits-of-online-learning/

Kempa, R.F., & Palmer, C.R. (1974). The effectiveness of video-tape recorded demonstrations in the learning of manipulative skills in practical chemistry. *British Journal of Educational Technology, 5*(1), 627-671.

Koller, V., Harvey, S., & Magnotta, M. (n.d.). Technology-based learning strategies. Retrieved from https://www.business-access.com/about/techbasedlearningstrategies.pdf

Luka Ngoyi, (2013). Benefits and Challenges Associated with Using Virtual Laboratories and Solutions to Overcome Them. Degree of Doctor of Philosophy in Career and Technical Education. Virginia Polytechnic Institute and State University, Blacksburg, VA

Mansur Ahmed et. Al. (2021). Automated image analysis for quantification of materials microstructure evolution. *Modelling and Simulation in Material Science and Engineering, vol 29*, no. 5.

Max Planck, (2000). Virtual Laboratory. Essays and Resources on Experimentalization of Life. Retrieved from https://vlp.mpiwg-berlin.mpg.de/essays/index.html

Meijering E, Smal I, Danuser G. 2006. Tracking in molecular bioimaging. Signal Process Mag IEEE 23:46-53.

Meloan, C.E. (1971). The use of tape recorders, cartridge films, and real samples in laboratories. *Journal of Chemical Education, 48*(2), 139-141.

Mostafa Elhashash, (2020). All You Need to Know About Virtual Labs. Retrieved from https://blog.praxilabs.com/2020/04/22/all-you-need-to-know-about-virtual-labs/

Patterson, A. (1939). "The Scherrer Formula for X-Ray Particle Size Determination". *Phys. Rev.* 56 (10): 978–982.

Perkins, K., Adams, W., Dubson, M., Finkelstein, N., Reid, S., Wieman, C., &LeMaster, R.

(2006). PhET: Interactive simulations for teaching and learning physics. *The Physics Teacher,* 44(1), 18-23.

Pham DL, Xu C, Prince JL. (2000). Current methods in medical image segmentation. Annu Rev Biomed Eng 2:315-337.

Preoyati Khan, (2017). Cluster Based Image Processing for ImageJ. Kent State University in partial fulfillment of the requirements for the degree of Master of Science.

Robert M. Haralick, Linda G. Shapiro, (1985). "Image segmentation techniques", *Computer Vision, Graphics, and Image Processing, vol. 29*, no.1, pp. 100-132.

Safar Saeed Mohammed, (2019). Basic Difference between Crystalline & Polycrystalline Material. Retrieved from https://www.researchgate.net/post/Basic-Difference-between-Crystalline-Polycrystalline-Material

Sarkar, S, (2012). The role of information and communication technology (ICT) in higher education for the 21st century. *Science, 1*(1), pp. 30-41.

SERC-Carleton, (2021). Intro to ImageJ – SERC-Carleton. Retrieved from https://serc.carleton.edu/serc/quick_url.html

Schindelin, J., Rueden, C. T., Hiner, M. C., & Eliceiri, K. W. (2015). The ImageJ ecosystem: An open platform for biomedical image analysis. *Molecular Reproduction and Development, 82*(7-8), 518–529.

Schmidgen, Henning; Evans, Rand B., (2003). The Virtual Laboratory: A New On-Line Resource for the History of Psychology. *History of Psychology*, 6 (2), p.208-213.

Sife, A. S., Lwoga, E. T., & Sanga, C. (2007). New technologies for teaching and learning: challenges for higher learning institutions in developing countries. International *Journal of Education and Development using Information and Communication Technology,* 3(2), 57-67.

Sparrow, L., Sparrow, H. & Swan P. (2000). Student-centered learning: Is it possible? In Herrmann, A., and Kulski, M.M. (Eds), *Flexible futures in tertiary teaching*. Proceedings of the 9th Annual Teaching Learning Forum

S. Szenasi, (2013). "Medical image segmentation with split-and-merge method," *In Proc. of 5th IEEE International Symposium on Logistics and Industrial Informatics (LINDI 2013)*, pp.137-140.

Staker, H. & Horn, M. B. (2012). Classifying K-12 Blended learning. Innosight Institute, CA,

USA. Retrieved from http://www.innosightinstitute.org/innosight/wp-content/uploads/2012/05/Classifying-K-12-blended-learning2.pdf

Sven Dierig, Jörg Kantel & Henning Schmidgen, (2000). The Virtual Laboratory for Physiology. A *Project in Digitalising the History of Experimentalisation of Nineteenth-Century Life Sciences, 1*(1), pg5-8.

Tüysüz C. (2010). The Effect of the virtual laboratory on students' achievement and attitude in chemistry. *International Online Journal of Educational Sciences, 2*(1), 37-53.

Twigg, C. (1995). The value of independent study. Educom Review. 30(4). Retrieved from http://www.educause.edu/pub/er/review/reviewArticles/30424.html

Valentina Arkorful and Nelly Abaidoo, (2014). The role of e-learning, the advantages and disadvantages of its adoption in Higher Education. *International Journal of Education and Research, 2*(12), pg 397-404

Wieman, C., & Perkins, K. (2005). Transforming physics education. *Physics Today, 58(11),* 36-41.

Woodfield, B. F., Catlin, H. R., Waddoups, G. L., Moore, M. S., Swan, R., Allen, R., & Bodily, G. (2004). The virtual chemLab project: A realistic and sophisticated simulation of inorganic qualitative analysis. *Journal of Chemical Education, 81*, 1672-1678.

XRD Crystallite (grain) Size Calculator (Scherrer Equation) - InstaNANO. https://instanano.com/characterization/calculator/xrd/crystallite-size/ (accessed June 27th, 2021).

APPENDIX A

Example of Questionnaires (Google Form)

Section A (personality detail)

Matric no.: _____

Gender:

	Male
	Female

Course:

	Bachelor of Science in Physics with Honors
	Bachelor of Science in Instrumentation Science with Honors
	Bachelor of Science in Material Science with Honors
	Bachelor of Science in Physics Education with Honors
	Others

Current Semester:

	1
	2
	3
	4
	5
	6
	7
	8

Have you taken the course PHY4204 Analytical Methods of Structure and Microstructure before?

	Yes
	No

Section B (online class learning)

1. How do you feel about online class?

_____

2. Which do you like? Virtual class learning or Face-to-Face class learning?

	Virtual Class Learning
	Face-to-Face Class Learning

3. What do you think about the virtual class learning/ virtual lab demonstration?

	Allow flexibility in online learning.
	Affordable alternative from physical class/ lab.
	Online class/lab can provide a visual aid to improve understanding and learning.
	An online class/lab can ensure students' safety, especially during the pandemic time.
	All above

4. During the Covid-19 pandemic time, which method do you prefer? Virtual lab or a face-to-face lab?

	Virtual Lab
	Face-to-face Lab

5. What are the benefits that you think of for your option above?

_____

6. Which one do you think you will gain more experience in doing lab?

	Online Lab
	Physical Lab

7. Which one do you think is harder to understand the demonstration?

	Online Lab
	Physical Lab

8. What is the best method of doing an online lab? Video demonstration or Online live demonstration?

	Video demonstration
	Online live demonstration

9. In your opinion, what is the best for a video lab demonstration?

	Can conduct experiments in-person/ group at home via a computer in a time-efficient and cost-effective way.
	Can provide a safe environment with less/ without the need for supervision.
	Virtual lab experiences can provide experiences the same with hands-on/physical laboratory.
	All above

Section C (how is the video)

From the rating, 1-No, not at all while 5-Yes, certainly. Please rate your responses.

Question	**Rating**				
	1	**2**	**3**	**4**	**5**
The video topic is presented well and the lab demonstration is clearly understood.					
The lab video showed a clear lab demonstration, as followed by the lab manual instruction.					
The video lab demonstration video is good and interactive.					
The video has good visuals and used good camera angles.					
The video has good sound and has a clear sound.					
The video has a clear script was written and a dialogue lines presentation.					

I found the lab is easy to do after watching the video lab demonstration.					
I found the ImageJ software is easy to access after watching the video.					
I found this video can be used in online laboratory classes wisely and very useful to students?					

Section D (how they feel about the video)

From the rating, 1-No, not at all while 5-Yes, certainly. Please rate your responds.

Question	**Rating**				
	1	**2**	**3**	**4**	**5**
Do you like the video demonstration?					
Did you find the video interesting to learn?					
Do you think the video is easy for you to understand?					
Do you find the online lab is more interesting after watching the video lab demonstration?					
Do you think the online lab is more challenging compared to the hands-on/ face-to-face lab?					
I found the video is short and can keep students engaged.					

The video helps me to understand well the experiment topic.					
I can watch and repeat to watch the video anytime when I needed.					
I can watch the video and do my laboratory task in my flexible time.					
I can watch the video myself and do my laboratory task with less supervision from the lab instructor.					
The lab video demonstration is very useful and help me a lot to complete my lab assignment of the course.					

Is there any improvement that needs to do about the video demonstration?

_____

APPENDIX B

Table showed the percentage of students that take PHY4204 course

	Student that taken this course before	**Students that did not taken this course before**
Percentage (%)	53.3	46.7
Total	16	14

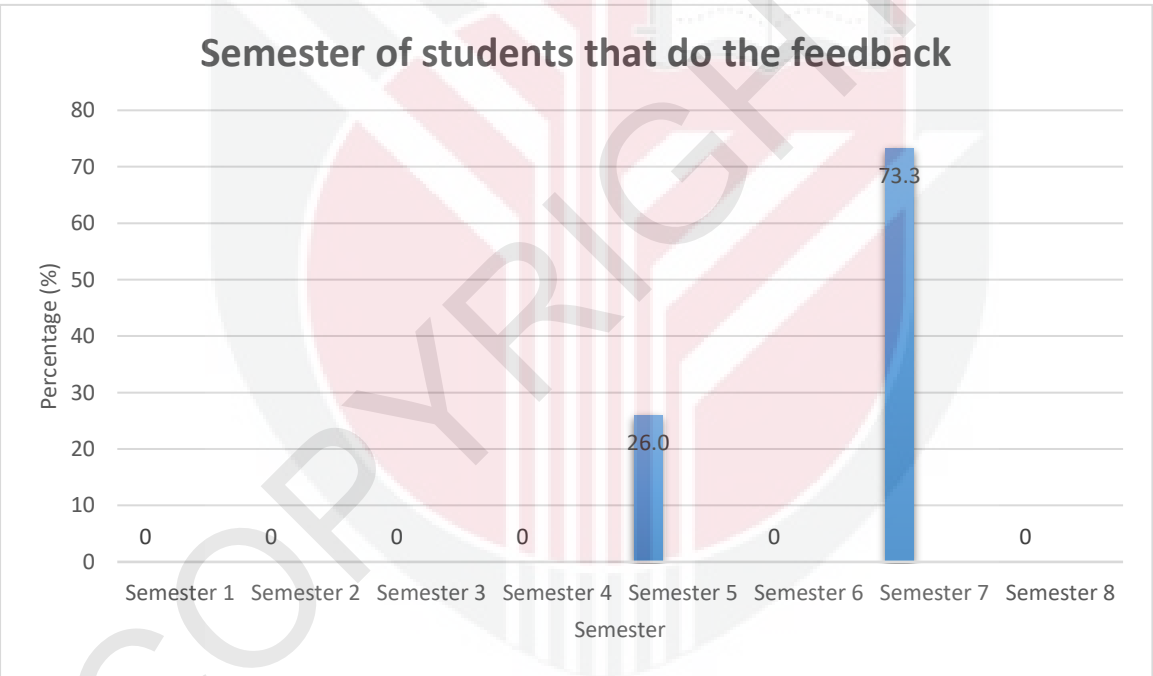
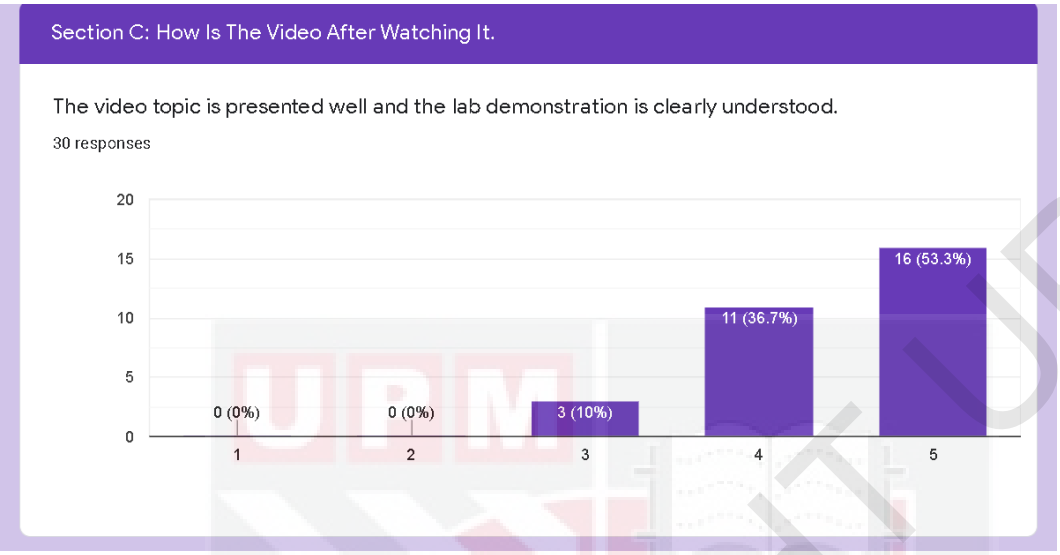
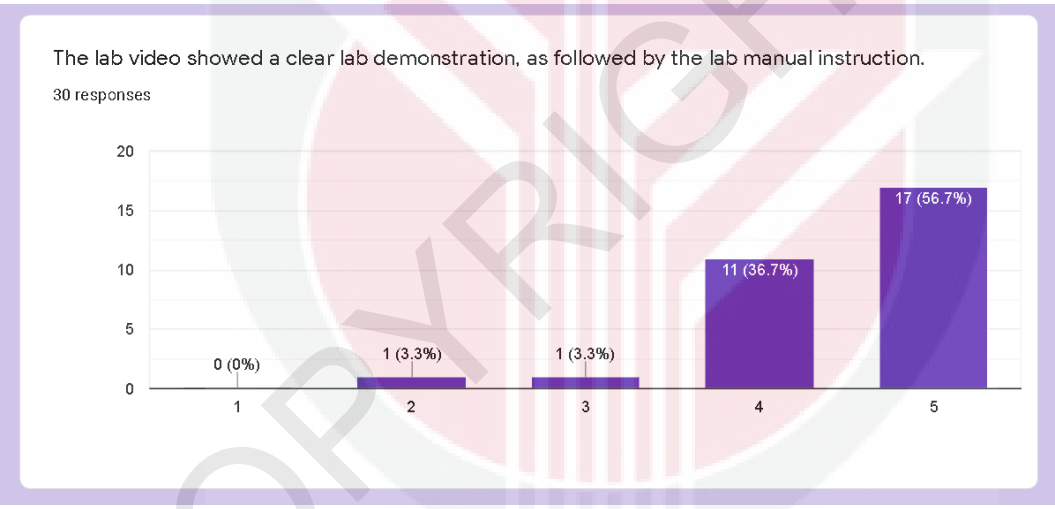
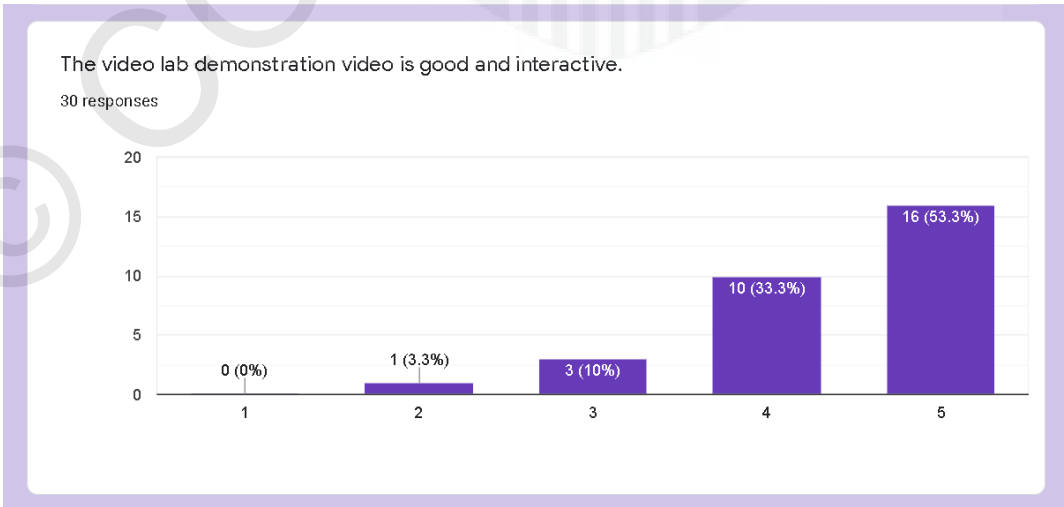


Figure showed the percentage of semester that students do the feedback form

Students rating scale for the video laboratory demonstration.

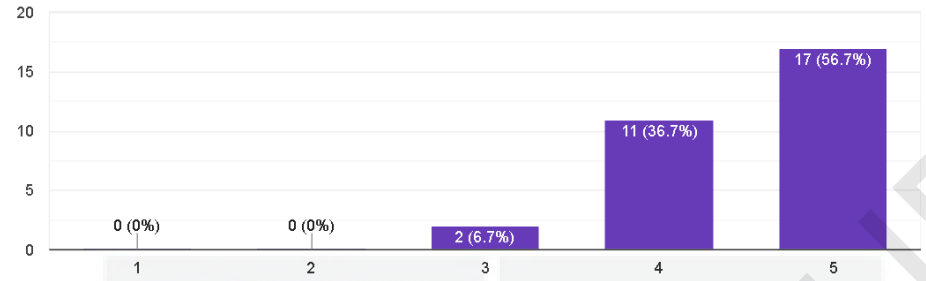






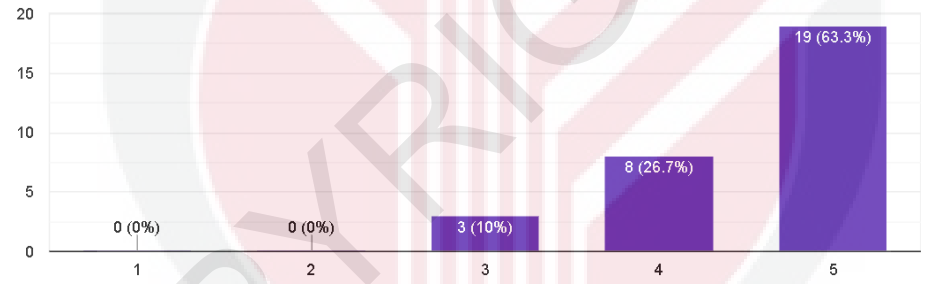
The video has good visuals and used good camera angles.

30 responses



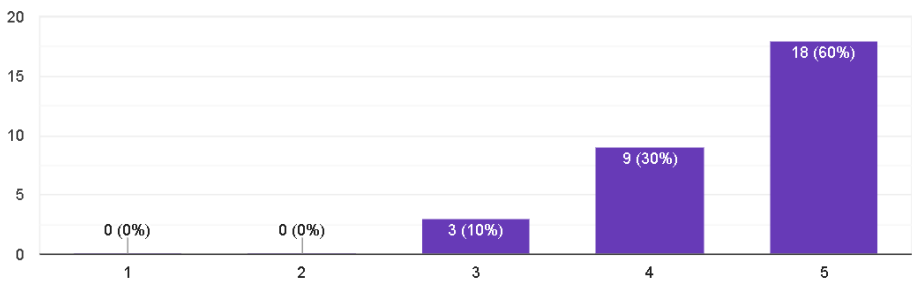
The video has good sound and has a clear sound.

30 responses



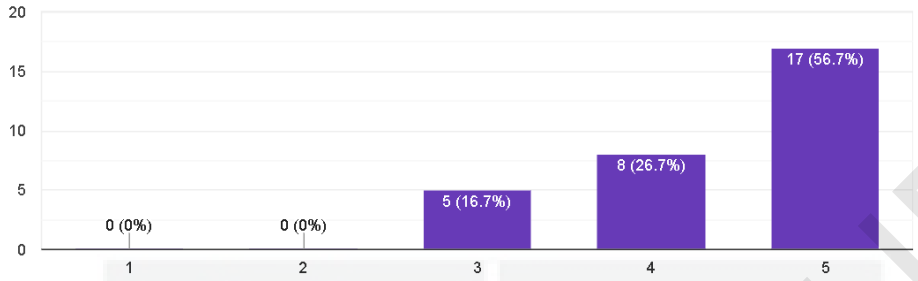
The video has a clear script was written and a dialogue lines presentation.

30 responses



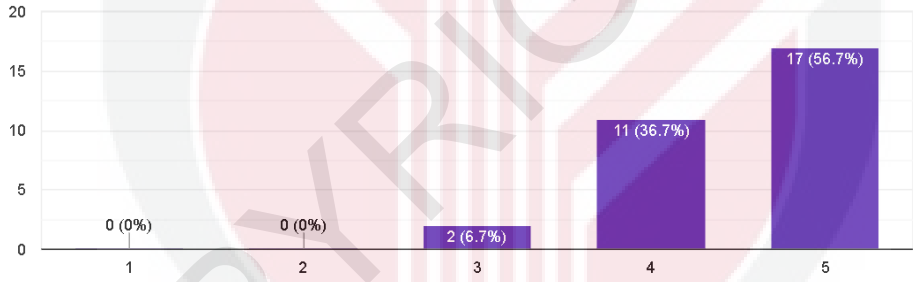
I found the lab is easy to do after watching the video lab demonstration.

30 responses



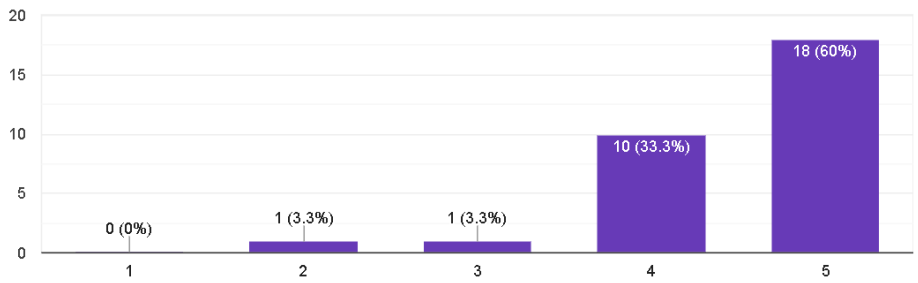
I found the ImageJ software is easy to access after watching the video.

30 responses

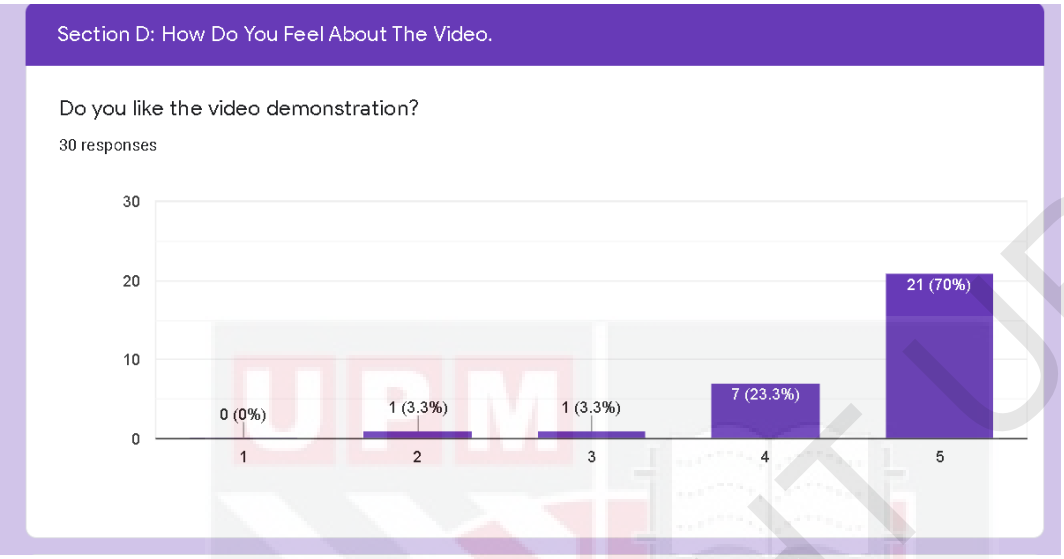


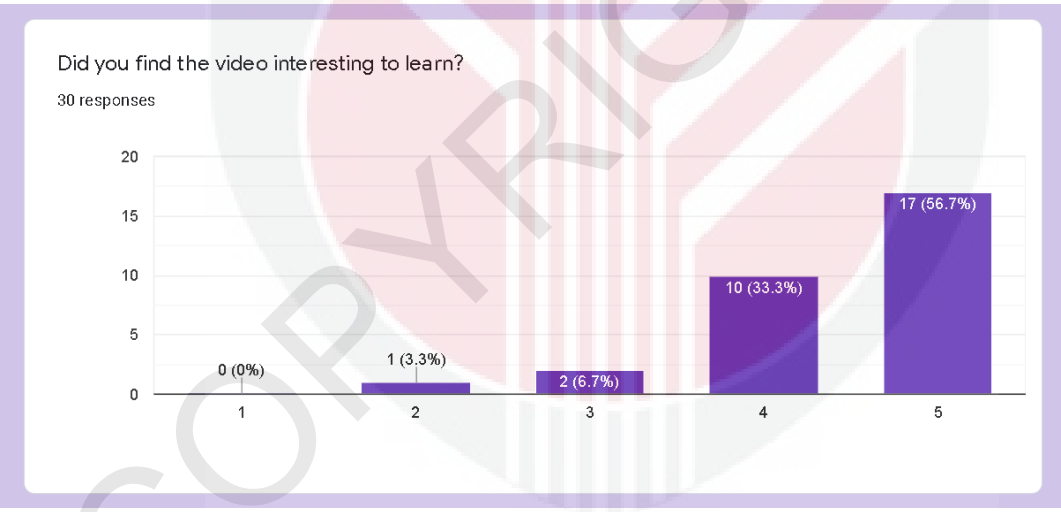
I found this video can be used in online laboratory classes wisely and very useful to students?

30 responses



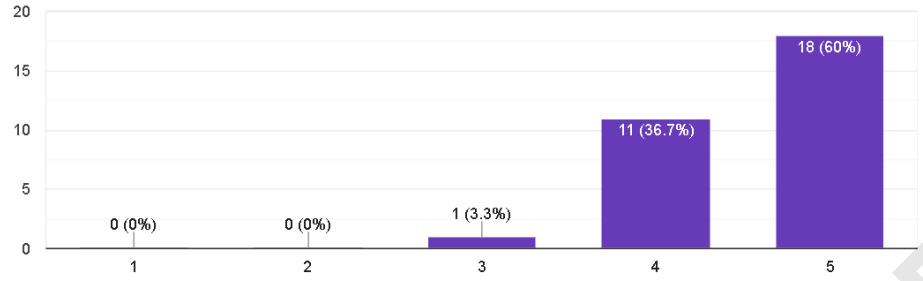
Students rating scale on how they feel about the video.





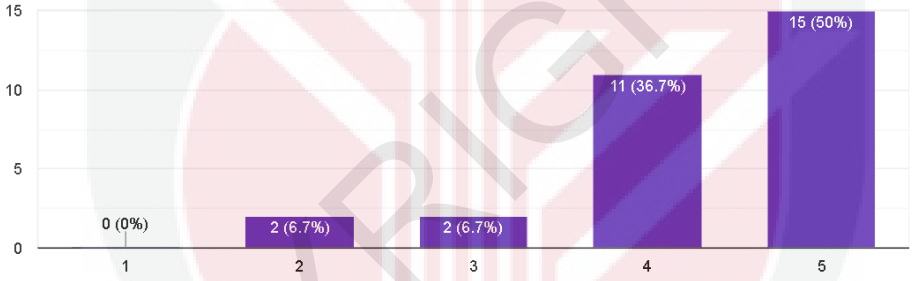
Do you think the video is easy for you to understand?

30 responses



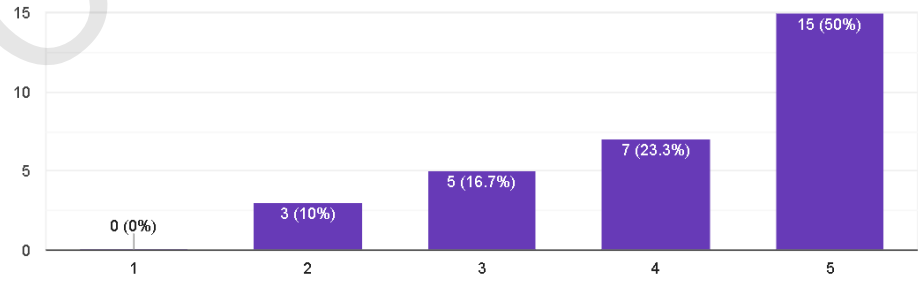
Do you find the online lab is more interesting after watching the video lab demonstration?

30 responses



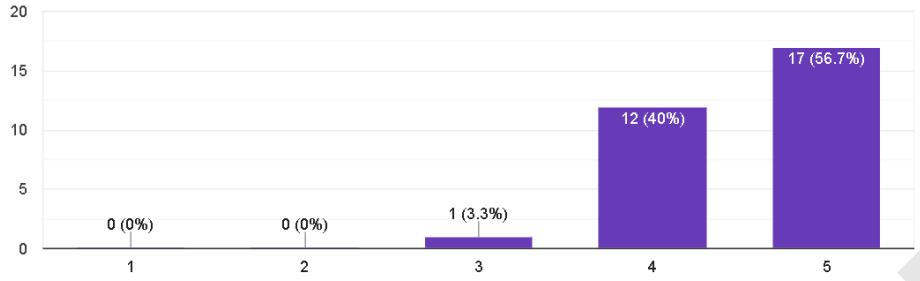
Do you think the online lab is more challenging compared to the hands-on/ face-to-face lab?

30 responses



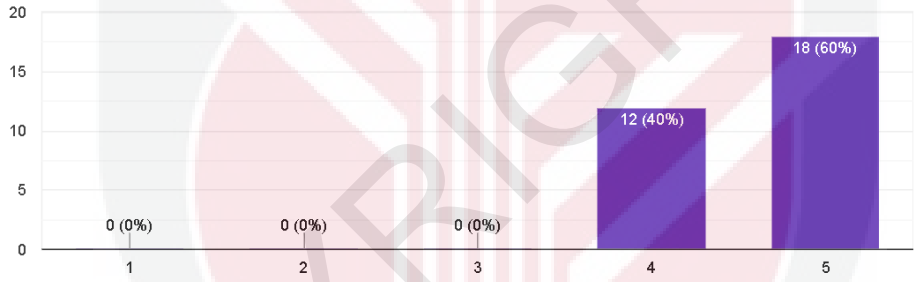
I found the video is short and can keep students engaged.

30 responses



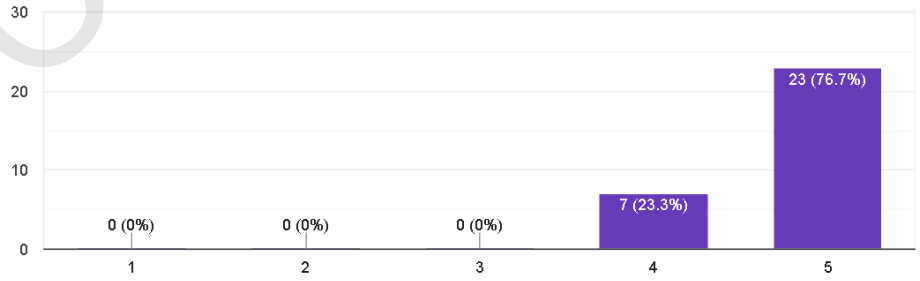
The video help me to undertand well the experiment topic.

30 responses



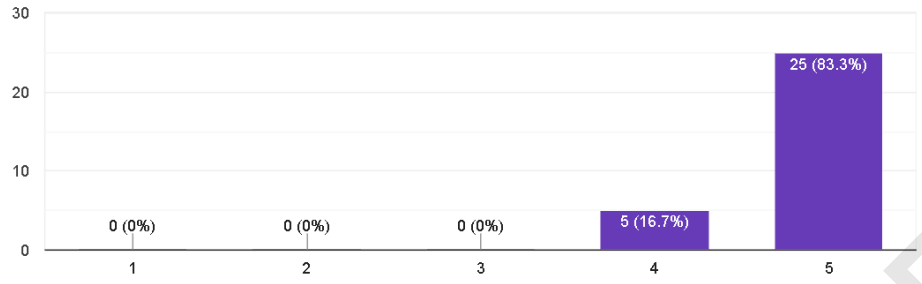
I can watch and repeat to watch the video anytime when I needed.

30 responses



I can watch the video and do my laboratory task in my flexible time.

30 responses



I can watch the video myself and do my laboratory task with less supervision from the lab instructor.

30 responses

The lab video demonstration is very useful and help me a lot to complete my lab assignment of the course.

30 responses