

# Analysis of Higher Order Thinking Skills (HOTs) on Simple Harmonic Motion Concept Using Virtual Laboratory Based on VBA Excel Study in Physics Education Students of Universitas Cenderawasih

Muhammad Akbar<sup>1,\*</sup> Indah Slamet Budiarti<sup>1</sup>

<sup>1</sup> Department of Physics Education, Universitas Cenderawasih, Papua, Indonesia

\*Corresponding author. Email: [akbartahanurb@gmail.com](mailto:akbartahanurb@gmail.com)

## ABSTRACT

Higher Order Thinking Skills (HOTs) is one of mastery skills owned by students in higher education to meet the challenges of 21<sup>st</sup> century. Virtual laboratory based on VBA excel is an application that can help to preserve learning during 21<sup>st</sup> century and pandemic era. The aim of this study was to analyze higher order thinking skills (HOTs) on simple harmonic motion concepts using virtual laboratory based on VBA excel in physics education students of Universitas Cenderawasih, Papua, Indonesia. The research approach was descriptive quantitative method. The population of this research were all higher students in physics education of Universitas Cenderawasih, Papua, Indonesia. Samples were 23 students and they were chosen from cluster random sampling technique. Based on the results of data analysis, it was concluded that 28.26% of the students mastered HOTs in the analysis stage, 16.34% of the students mastered HOTs in evaluation, and 13.04% of the students mastered HOTs in creation.

**Keywords:** Higher Order Thinking Skills, Simple Harmonic Motion, VBA Excel.

## 1. INTRODUCTION

The Covid-19 pandemic has shocked the world. Nearly a hundred countries are experiencing the Covid-19 pandemic, including Indonesia [1]. The government's policy to reduce the number of victims is enough to affect the joints of people's lives in carrying out daily activities [2]. One of them is large-scale social restrictions where all gathering activities are closed which has implications for not carrying out teaching and learning activities at schools [3]. Learning during the pandemic has turned into learning that is based on a combination of online and offline or only online. It is to prevent the spread of the virus with a wider range [4].

The policy of the ministry of education and culture is to eliminate teaching and learning activities in schools and universities in areas that have a fairly large number of Covid-19 victims and make online teaching and learning activities [5]. The online learning system is an implementation of distance education that aims to implement access to quality learning [6]. Online education is solid as a teaching and learning process carried out by an educational institution where students

and teachers are not in the same location so that an interactive telecommunications system is needed to connect the two and the resources needed in it [7]. Online lecture policies require extra readiness for teachers to explain so that the material provided can be understood well by students [8].

The results of observations made to students of the Physics Education Study Program, Universitas Cenderawasih, students already have high enough confidence in understanding and working on problems related to the derivation of a Physics equation. Otherwise, students were given a cognitive test that contains high-level thinking skills and abstraction and students experience low grades. It is because physics textbooks only contain various physical equations without visual examples [9]. Thus, students cannot understand the translation of a physical equation and cannot visualize an equation [10], [11]. The equation is not easy to understand and apply in everyday life [12].

One way to improve students' ability to understand an equation is to do the practicum [13]. Laboratory activities are essential components in the physics learning

process [14]. The learning process carried out by practicum allows students to develop basic skills in observing, analyzing data, determining conclusions, communication, and teamwork [15]. Apart from that, practical activities as proof of a concept can develop thinking skills through problem solving to help students find their concepts [16]. The laboratory is defined as a vehicle for learning and a way of learning [17].

Experimental activities carried out in the laboratory enable students to improve their academic and social skills [14], [18], [19]. Students' academic skills are in the form of mastery of concepts, developing learning skills, conducting their experiments, and developing various scientific skills [20]. Viewed from the social side of experimental activities, students can cultivate an attitude of respect for the opinions of others, learn to communicate an idea, and teamwork [21]. An experiment in laboratories can help students to improve academic and social skills [22]. Besides, it also has several obstacles, namely the lack of facilities, requiring a large enough time allocation, and inadequate laboratory conditions. The problem sometimes makes teachers carry out activities in the laboratory in dense groups. It results in safety risks for students [17].

In addition, the policy of eliminating teaching and learning activities on campus makes practical activities impossible [8]. It is what makes educators at any level of education need facilities to condition students or students to do the practicum [23]. One of the tactics that can be done is to move the practicum activities in the laboratory to other facilities. Practicum can be done virtually through online classes by creating a virtual laboratory as a learning tool [24]. Current technological developments make experiments carried out in laboratories can be done virtually, which is commonly called a virtual laboratory [25]. A virtual laboratory simulates the environment and processes that exist in a real laboratory [26]. Learners change their theoretical knowledge into practical knowledge through experiments [27]. The process of making experiments virtually is designed and sequenced in such a way to make it seem real like doing a practicum in a laboratory.

A virtual laboratory is defined as software that can simulate a practicum activity such as in a laboratory [28]. The concept of a virtual laboratory is an experiment. Experimentation is the process of combining data with a series of activities to obtain experimental results [29]. A virtual experiment is a complex workflow [30]. It is performed iteratively from a program installed on a computer. Virtual experiments provide a networked and app-based practical experience [31]. Students will not get data results with error analysis as is usually found in real practicums [32]. However, students can still get physical and mathematical concepts from a lesson [33]. Virtual experiments can help students who do not have access to real practicums due to the absence of practical teaching

aids at school or in the environment where they are studying [34], [35].

Simulation on a computer is one of the learning media that can present physical phenomena ideally, safely, and cheaply [24], [36]. It also can cover the limitations of existing laboratories in educational institutions [37]. To make a simulation or animation on a computer, developers need software. One of the software, that is often used in making a simulation of physical phenomena, is Visual Basic for Application (VBA). VBA is a feature in Microsoft Excel that can be used to automate some aspects of Excel [38]. Besides, it can store repetitive actions and make visualizations and simulations of mathematical equations effectively and efficiently [39]–[41].

Previous researcher created a simulation using the VBA Excel application, namely objects that are released horizontally and objects are released vertically using [42]. Other researcher also made a simulation on the phenomenon of the speed selector using the Excel VBA application [40]. VBA excel is widely used in making simulations, animations, and programs used for physics learning purposes. Several researchers create virtual animation programs that can be used as virtual laboratories to improve students' security in physics concepts [34], [43]–[46]. Based on the research that has been done, VBA excel will still develop as a virtual laboratory media, especially in the application of physics concepts.

Based on initial observations to students of the Universitas Cenderawasih Physics Education study program, almost 100% of students have a computer or laptop based on the Windows operating system and Microsoft Excel application. In addition, researchers also conducted preliminary research by interviewing Physics Education students at Universitas Cenderawasih to find out what physics concepts were difficult for them to understand or understand. As many as 64% of students answered that the concept of the simple harmonic motion is a physics concept that is difficult to understand this semester. Students must achieve this competency by understanding and being able to do practical work and describe the analysis of the process of the occurrence of harmonic motion physically and mathematically. The concept of the harmonic motion is complex. Students, who do not have good apperception skills for vibrations and mathematical trigonometric equations, will have difficulty. The absence of real practicum during the pandemic also makes this concept difficult to understand [47].

Understanding the concept of simple harmonic motion in this study focuses on three students' thinking skills, namely analytical thinking skills, critical thinking skills, and creative thinking skills. All three are aspects of higher-order thinking skills (HOTS) [48]. We focus on HOTS as a reference for competency achievement for

understanding the concept of simple harmonic motion because students need thinking skills training to apply the concept contextually. Simple harmonic motion is closely related to everyday life. Some contextual events related to simple harmonic motion are swings, pendulum clocks, the manufacture of spring mattresses, the car industry in the shock breaker section, and the manufacture of guitar strings [44], [49], [50]. Therefore, educators need to analyze and improve students' HOTs during the process of understanding the concept of simple harmonic motion. Based on the findings in the initial study, we also found that the measurement of HOTs of Physics Education students at Universitas Cenderawasih had never been carried out on simple harmonic motion material. In addition, the application of virtual practicum with VBA Excel is allegedly a means to measure students' HOTs levels based on previous research on other physics concepts [51].

From the background and initial findings found in the field, the researchers proposed an analysis of student concept understanding based on HOTs indicators for learning physics on simple harmonic motion material through a virtual laboratory based on VBA Excel for students of the Universitas Cenderawasih Physics Education study program. The research question is how the pattern and description of the HOTs level of Physics Education students at Universitas Cenderawasih in learning physics for simple harmonic motion material with a virtual laboratory based on VBA Excel. The purpose of our research is to obtain student HOTs level results and make it a reference for evaluating the competency achievements of Physics Education students during the online learning process during the pandemic.

## 2. METHOD

The method used in this research was descriptive quantitative. The aim of this study was to analyze students' HOTs level on simple harmonic motion concepts using virtual laboratory based on VBA excel in physics education students of Universitas Cenderawasih, Papua, Indonesia. The population of this research were all higher students in physics education of Universitas Cenderawasih, Papua, Indonesia. Samples were 23 students. We used cluster random sampling technique because we intended to choose the samples from the population that can be an unbiased representation of the group [52]. This is considered a fair way to select a sample from a larger population because every member of the population has an equal chance of being selected [53]. Every student in physics education has the same chance of being the research sample. It is a requirement of quantitative research approach. Research was conducted during the second term of academic year 2020/2021.

Data were collected by applying purposive multiple-choice tests and interviews. The tests consisted of eight

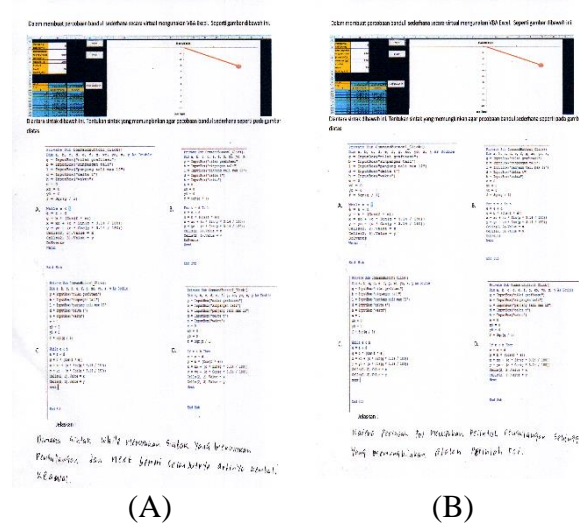
numbers. Two item questions were problems of simple harmonic motion on pendulum, three item questions were simple harmonic motion on spring, and three item questions were damped oscillation. Interviews were taken to collect data about students' scientific reasonings of the answer written on the answer sheets. Besides, interviews were conducted to confirm whether students are confident to their answers or not so that the researcher can measure students' level of HOTs during the physics learning process of simple harmonic motion. Data analysis was conducted to analyze the pattern of students' HOTs level in simple harmonic motion concept based on VBA Excel as virtual laboratory.

## 3. RESULTS AND DISCUSSION

We analyzed the data and divided into three parts of analysis. The first analysis was related to students' answer to simple harmonic motion on pendulum, the second analysis was related to students' answer to simple harmonic motion on spring, and the third analysis was related to students' answer to damped oscillation. Then, we resumed the analysis based on students' description and level of HOTs in physics learning to material simple harmonic motion.

### 3.1. Analysis of Students' Answer Related to Simple Harmonic Motion on Pendulum

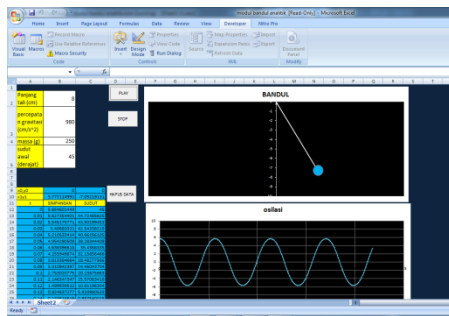
We analyzed students' answer related to simple harmonic motion on pendulum. After the virtual laboratory based on VBA Excel to simple harmonic motion on pendulum concept was implemented during physics learning, students were given two item questions. The example of the students' answer on the answer sheet to simple harmonic motion concept is presented in Figure 1.



**Figure 1** Student's answer on simple harmonic oscillation on a pendulum.

In the case in Figure 1, students A and B have difficulty in using Excel's VBA syntax. For example, student A mentions that the pair of "While" is "Next" doesn't fit the context because the pair of while syntax does events went or loop, while respondent B only knows the syntax function of "For", but student B doesn't know the pair of syntax to perform repeated calculations, namely "Next". The other 21 students were unable to explain the reason. The problem about harmonic oscillation on a simple pendulum concept above requires the cognitive thinking stage from knowledge, understanding, application, analysis, evaluation, and creation. Thus, the problem covers the creation thinking stage. Based on the answers from two students, it can be concluded that the three students have not been able to create or make the next stage with the VBA Excel application on the concept of harmonic oscillation on a simple pendulum.

Figure 2 is an example of a visual or simulation of using a Virtual laboratory based on VBA Excel on a computer or laptop used by students during physics learning for simple harmonic motion material in the predecessor. Students do practicums with interactive visuals. The data are tabulated in the table and analyzed to find the physical and mathematical concepts of the relationship between variables in simple harmonic motion on a swing.



**Figure 2** Example of harmonic oscillation on a pendulum using VBA Excel.

The correct answer in the case of Figure 1 is A. In operating a virtual simulation of a simple pendulum animation using VBA Excel, students should begin to know the syntax that can perform repeated calculations, namely "For" and "While". The next stage is knowing the syntax for repeated calculations, the next step is to determine the simple pendulum equation that we will use, namely on the axes in Equation (1).

$$x = l \sin \sqrt{\frac{g}{l}} t \quad (1)$$

$$y = l \cos \sqrt{\frac{g}{l}} t \quad (2)$$

after that enter the command to perform the repetition command, namely if using "While" then the command is closed with went or loop while "For" can be closed with "Next", as shown in Figure 2.

This is reinforced by interviews with students after working on the questions given on the concept of vibration on a swing. The student answered that he did not understand the VBA Excel syntax to get the relationship between the vibration variables on the swing because he forgot and did not understand the concept of vibration in general. This is confirmed by questions about the apperception that students have before learning about the vibrations of the pendulum. Students forget and/or do not know about the vibration equations that they have learned in the previous meeting. Some students answered that they did not understand trigonometric equations which are mathematical equations for simple harmonic motion. The use of sine and cosine functions makes it difficult for them to understand the concept of vibration on a swing even though it has been visualized through a virtual laboratory based on VBA Excel.

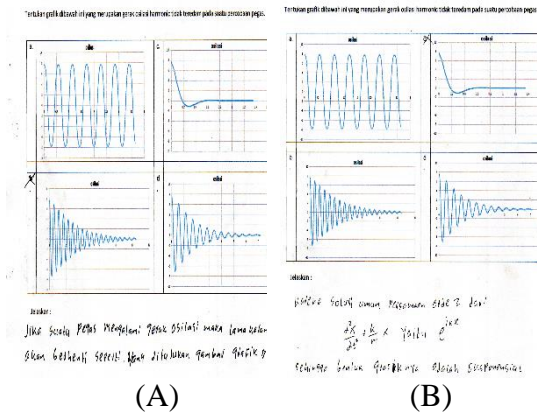
"I was confused when using VBA Excel because I had never been taught to operate it before. I use Excel only for computer practicum and descriptive statistical data processing. The application of Excel VBA to the concept of vibration on a pendulum is difficult for me to understand because the syntax requires mathematical trigonometric equations." – Student A

The discovery of the concept of vibration on swing in this study is supported by previous research which also used VBA Excel. The use of VBA Excel in learning physics on the concept of vibration on a swing can be used to analyze the increase in students' learning achievement, enthusiasm, and thinking skills [49], [54]. However, the use of VBA Excel requires practice because not all students are familiar with the code or syntax in Excel [55]. Especially if students do not have a good apperception of vibrations and trigonometric mathematical equations. Students actually have difficulty understanding the concept.

### 3.2. Analysis of Students' Answer Related to Simple Harmonic Motion on Spring

We analyzed students' answer related to simple harmonic motion on spring. After the virtual laboratory based on VBA Excel to simple harmonic motion or oscillation on spring concept was implemented during physics learning, students were given two item questions. The example of the students' answer on the answer sheet to simple harmonic motion concept is presented in Figure 3.



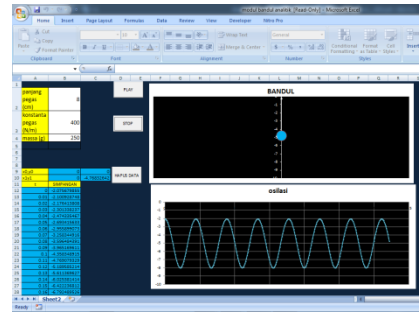


**Figure 3** Student's answer on simple harmonic oscillation on a spring.

Based on the answers in Figure 3, it can be concluded that student A only sees natural phenomena, namely in doing spring work. However, the phenomenon seen by student A is the phenomenon of damped harmonic oscillations due to air friction so that the spring will stop moving. Student B looks at the general solution of an ordinary differential equation of order 2. However, student B does not know that the general solution to the equation of an undamped spring is sinusoidal, not exponential. The problem about harmonic oscillation in the spring concept above requires the cognitive thinking stage from knowledge, understanding, application, analysis, and evaluation. Thus, the problem covers the evaluation thinking stage. Based on Figure 3, it can be concluded that students have not been able to evaluate the concept of harmonic oscillation in a spring. Graph A shows a sinusoidal graph where the solution to the equation of undamped oscillatory motion is, as shown in Figure 4. Graphs B and D are graphs of damped oscillations due to the oscillatory motion which decays and then stops. Graph C is a graph of forced damped oscillation, which is shown by an exponential decay graph.

Figure 4 is an example of a visual or simulation of using a Virtual laboratory based on VBA Excel on a computer or laptop that is used by students during physics learning for simple harmonic motion material in the predecessor. Students do practicums with interactive visuals. The data are tabulated in the table and analyzed to find the physical and mathematical concepts of the relationship between variables in the simple harmonic motion of a spring.

The harmonic motion of the spring shown in Figure 4 shows that the spring can be changed in weight. There is a sinusoidal wave that describes the process of vibration in a spring that has been given a certain mass. At the peak of the vibration, the amplitude can be determined. The data from the students' virtual experiments were then tabulated in a blue data table.



**Figure 4** Example of harmonic oscillation on a spring using VBA Excel.

The period of oscillation in the mass-spring system can be found from the mass equation and the spring constant. In other words, the length of time required by one vibration is determined by the magnitude of the spring constant itself and the mass of the load hanging on the spring. By using VBA Excel, students can see a simulation of the occurrence of vibration if the constant and mass of the load are changed. After the end of learning with VBA Excel, students are expected to be able to analyze the relationship between vibration period, vibration frequency, mass, and spring constant. Analysis of the relationship of variables on the vibration of the spring can represent observations on analytical thinking skills. The evaluation stage is shown by students when concluding the data that has been obtained from VBA Excel. The process of students changing the size of the variable to get some diverse data can indicate creative thinking skills.

This is reinforced by interviews with students after working on the questions given on the concept of vibration on the spring. The student answered that he was confused by the concept of vibration in spring because he was not familiar with ordinary differential mathematical equations. This makes students unable to distinguish exactly how the actual graph of the vibration equation in the spring is; whether sinusoidal or exponential. Students are confused with the concept of damped vibrations. In the concept of vibration in the spring, if there are no other parameters that cause the reciprocating motion to stop, such as air friction, the vibration will continue. Analysis of the vibration graph this spring can determine critical analytical thinking skills in students. The use of a Virtual laboratory based on VBA Excel also makes students' creative thinking skills develop. Researchers can observe changes in students' thinking after using VBA Excel.

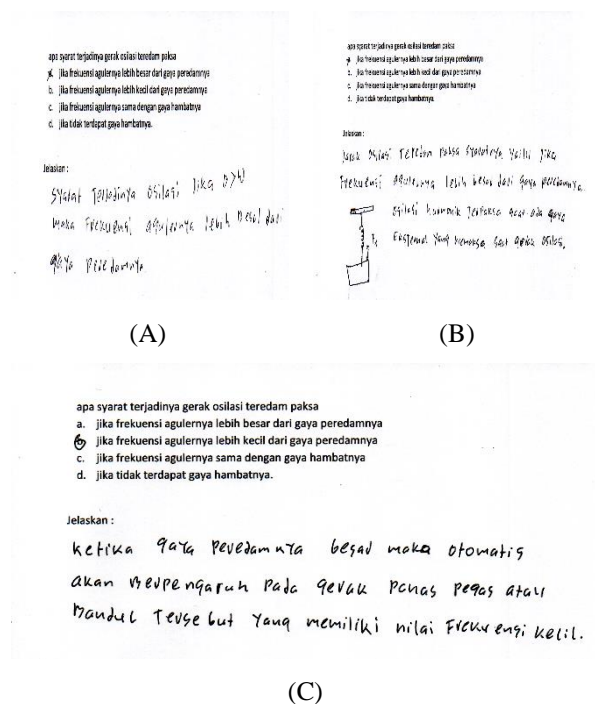
"The vibrating spring to my knowledge will eventually stop, so the graph must be exponential. The use of Excel VBA makes me confused when understanding the vibration graph in springs. I think the graph should be exponential, not sinusoidal." – Student B

The discovery of the concept of vibration in the spring in this study is supported by previous research which also

used VBA Excel. The use of VBA Excel in learning physics on the concept of vibration on a spring makes students understand more about the concept of harmonic vibration which has a sinusoidal graph because the vibration is not damped [56], [57]. It is well simulated by VBA Excel. The obstacle in learning the concept of vibration on springs using VBA Excel is the limited ability of students to operate Excel-based applications [42]. Even if students already know the Excel program well, VBA Excel is an add-on that requires an understanding of certain codes and syntax to get the expected data.

### 3.3. Analysis of Students' Answer Related to Damped Oscillation

We analyzed students' answer related to damped oscillation. After the virtual laboratory based on VBA Excel to damped oscillation concept was implemented during physics learning, students were given two item questions. The example of the students' answer on the answer sheet to damped oscillation concept is presented in Figure 5.

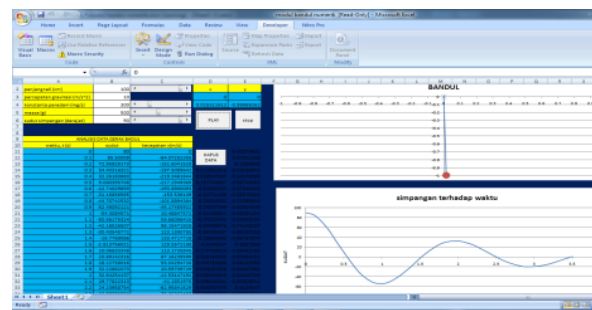


**Figure 5** Student's answer on damped oscillation.

Damped oscillations occur if the damping force  $B$  is much greater than the angular frequency so that the pendulum or spring loses its ability to perform oscillatory motion due to the large damping force, as shown in Figure 5. Students A and B have difficulty distinguishing between damping force and frequency. angular so that in taking the wrong conclusion, while student C has the right answer but the explanation is not quite right because student A explains the heat motion of the spring and

pendulum. The problem about the damped oscillatory motion concept above requires the cognitive thinking stage from knowledge, understanding, application, and analysis. Thus, the problem covers the analysis thinking stage. Based on Figure 5, it can be concluded that students are not able to analyze the concept of damped oscillatory motion presented in the problem after the implementation of a virtual laboratory based on VBA Excel.

Figure 6 is an example of a visual or simulation of using a virtual laboratory based on VBA Excel on a computer or laptop used by students during physics lessons for damped oscillatory motion material. Students do practicums with interactive visuals. The data are tabulated in the table and analyzed to find the physical and mathematical concepts of the relationship between variables in damped oscillating motion.



**Figure 6** Example of damped oscillation motion using VBA Excel.

The graph shown on the damped vibration visualization using a virtual laboratory based on VBA Excel is an exponential graph. Based on Figure 6, the vibration amplitude is getting lower and steeper, even approaching zero. This is due to the damping force that makes the vibrations stop after moving for a certain time; also experience a certain frequency and period. Damped vibrations are real vibrations in everyday life. Every swing that moves, will eventually stop if the driving force stops due to damping from friction with external forces. VBA Excel can describe this decrease in amplitude. This is by the concept of damped vibrations found by previous scientists. The angular velocity decreases and the vibration amplitude decreases.

This is supported by the existence of interviews with students after working on the questions given on the concept of damped vibrations. Students answered that the concept of damped vibration has another variable, namely damping force. When the damping force is greater than the angular frequency of the pendulum or spring's vibration, the vibrations will eventually stop for a certain time. Conversely, if the damping force is smaller than the angular frequency of the pendulum or spring vibration, the vibration is not damped and becomes a harmonic vibration. However, in reality, most of the vibrational motion is always damped because of the

external force factor that prevents the vibration to last forever.

“In damped vibrations or oscillations, the angular frequency is less than the damping force. This is a condition for the occurrence of damped vibrations. I answered answer B because I think the angular frequency affects the frequency of vibration. If the frequency of the spring or pendulum was small, it would stop faster and not make back and forth movements again.” – Student C

The discovery of the concept of vibration in the spring in this study is supported by previous research which also used VBA Excel. The use of VBA Excel in learning physics on the concept of damped vibrations on a spring or pendulum makes students understand more about the concept of harmonic vibrations which have an exponential graph because the vibrations are damped [44]. The positive side of using a virtual laboratory based on VBA Excel is the ease of visual practicum without the need for real teaching aids such as pendulums and springs which are usually not found in rural areas. Students can see the visualization of pendulum and spring movements through simulations presented by virtual experiments based on Excel VBA. It also facilitates practical work because students only need to use a laptop or computer and Excel software [58]. On the other hand, VBA Excel has not been able to visually describe the occurrence of damped vibrations optimally because students cannot observe with the five senses what parameters make the vibration of an object stops [56]. This can be a weakness that makes students unable to develop their thinking skills at the HOTS level because students cannot analyze errors or errors that are usually found during real practicums.

### 3.4. Analysis of Students' HOTS Level in Simple Harmonic Motion

The analysis of overall students' answer in the answer sheets were from item questions of simple harmonic motion (test consisted of eight numbers which are two item questions were problems of simple harmonic motion on pendulum, three item questions were simple harmonic motion on spring, and three item questions were damped oscillation). Percentage of student's conceptual understanding consistency represents the description and level of students' HOTS. The results were based on students' answers as seen on Table 1.

**Table 1.** Percentage of students' HOTS level and description

High Order Thinking Skills	Percentage (%)
Analysis	28.26
Evaluation	16.34
Creation	13.04

Based on Table 1, it can be seen that the highest domain of Bloom Taxonomy, which is the highest and lowest order of high order thinking skills shows average 28.26% and 13.04%. Table 1 also shows that students' high order thinking skills percentage did not reach 100%, this indicates that 42.36% of students had not achieved high order thinking skills, means that 42.36% of the students were still in low order thinking skills, particularly recognized as lower order thinking skills (LOTS). Thus, there were still 42.36% of students who achieved knowledge, understanding, and application domain. After further interviews were taken, it was manifested that lecturer applied learning methods were dominated by lecture methods and this was the first time that students were familiar with VBA Excel as a learning medium in a virtual laboratory on the concept of simple harmonic motion. Therefore, the students were not trained to practice their HOTS as HOTS were achieved from student's learning and teaching process.

## 4. CONCLUSION

he existence of a policy of eliminating teaching and learning activities on campus makes practicum activities impossible, so practicum facilities or virtual experiments are needed to help students understand a physics concept. The quantitative descriptive research method that has been carried out in this study is by applying a virtual laboratory based on VBA Excel. The research resulted in an overview and level of student HOTS at Physics Education of Cenderawasih University. A total of 23 students as a sample were selected from all students at Cenderawasih University as the population. Sample selection was done using cluster random sampling technique. Researchers obtained patterns and descriptions of the HOTS level of Physics Education students at Cenderawasih University in learning physics for simple harmonic motion material with a virtual laboratory based on VBA Excel. It was concluded that 28.26% of the students mastered HOTS in the analysis stage, 16.34% of the students mastered HOTS in evaluation, and 13.04% of the students mastered HOTS in creation. The results of the analysis related to the description and level of student HOTS will be used as a reference for evaluating the competency achievements of Physics Education students at Cenderawasih University during the online learning process during the pandemic.

## AUTHORS' CONTRIBUTIONS

The first author of this study had done the data collecting and implemented the virtual laboratory based on VBA Excel during the physics learning in Universitas Cenderawasih. The second author conducted the pilot study through observation and early interview to determine the need analysis regarding the physics concept material, distance learning during pandemic, and the use of laboratory during pandemic. Both authors

performed data analysis, assisted through research permission and funding, and did article writing.

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## REFERENCES

- [1] Novel Coronavirus Pneumonia Emergency Response Epidemiology Team, "[The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China].," *Zhonghua Liu Xing Bing Xue Za Zhi*, vol. 41, no. 2, pp. 145–151, Feb. 2020, doi: 10.3760/cma.j.issn.0254-6450.2020.02.003.
- [2] Y. Bai *et al.*, "Presumed Asymptomatic Carrier Transmission of COVID-19.," *JAMA*, Feb. 2020, doi: 10.1001/jama.2020.2565.
- [3] S. C. Ratzan, L. O. Gostin, N. Meshkati, R. M. Parker, and K. Rabin, "COVID-19: An Urgent Call for Coordinated, Trusted Sources to Tell Everyone What They Need to Know and Do," *NAM Perspect.*, Mar. 2020, doi: 10.31478/202003a.
- [4] Kompas, "Rangkaian Peristiwa Pertama Covid-19 – Bebas Akses." <https://bebas.kompas.id/baca/riset/2020/04/18/rangkaian-peristiwa-pertama-covid-19/> (accessed May 15, 2020).
- [5] A. Sadikin and A. Hamidah, "Pembelajaran Daring di Tengah Wabah Covid-19," *Biodik*, vol. 6, no. 2, pp. 214–224, 2020.
- [6] Z. Y. Zu *et al.*, "Coronavirus Disease 2019 (COVID-19): A Perspective from China," *Radiology*, p. 200490, Feb. 2020, doi: 10.1148/radiol.202000490.
- [7] M. Buheji and A. Buheji, "Planning Competency in the New Normal–Employability Competency in Post-COVID-19 Pandemic," *Int. J. Hum. Resour. Stud.*, vol. 10, no. 2, pp. 237–251, 2020.
- [8] L. N. Atiqoh, "RESPON ORANG TUA TERHADAP PEMBELAJARAN DARING PADA MASA PANDEMI COVID-19," *Thufuli J. Ilm. Pendidik. Islam Anak Usia Dini*, vol. 2, no. 1, pp. 45–52, 2020.
- [9] L. Fitriah, "Efektivitas Buku Ajar Fisika Dasar 1 Berintegrasi Imtak dan Kearifan Lokal Melalui Model Pengajaran Langsung," *Berk. Ilm. Pendidik. Fis.*, vol. 7, no. 2, p. 82, 2019, doi: 10.20527/bipf.v7i2.5909.
- [10] M. D. Prastika, M. Wati, and S. Suyidno, "The Effectiveness of Problem-Based Learning in Improving Students Scientific Literacy Skills and Scientific Attitudes," *Berk. Ilm. Pendidik. Fis.*, vol. 7, no. 3, p. 194, 2019, doi: 10.20527/bipf.v7i3.7027.
- [11] M. Fadilah, A. Permanasari, R. Riandi, and E. Maryani, "Analisis Karakteristik Kemampuan Literasi Sains Konteks Bencana Gempa Bumi Mahasiswa Pendidikan Ipa Pada Domain Pengetahuan Prosedural Dan Epistemik," *J. IPA Pembelajaran IPA*, vol. 4, no. 1, pp. 103–119, 2020, doi: 10.24815/jipi.v4i1.16651.
- [12] W. Kurniawan, J. Jufrida, F. R. Basuki, R. Ariani, and O. Fitaloka, "Virtual Laboratory Based Guided Inquiry: Viscosity Experiments," *JIPF (Jurnal Ilmu Pendidik. Fis.*, vol. 4, no. 2, p. 91, 2019, doi: 10.26737/jipf.v4i2.1069.
- [13] V. T. Irawan and E. Sutadji, "Blended learning based on schoology: Effort of improvement learning outcome and practicum chance in vocational high school," *Cogent Educ.*, vol. 4, no. 1, p. 1282031, 2017.
- [14] M. M. Chusni and A. Hasanah, "Pengaruh Kemampuan Pengelolaan Laboratorium dan Literasi Sainfik Terhadap Kesiapan Calon Guru Fisika," *Berk. Ilm. Pendidik. Fis.*, vol. 6, no. 3, p. 325, 2018, doi: 10.20527/bipf.v6i3.5222.
- [15] I. S. Budiarti, A. Suparmi, Sarwanto, and Harjana, "Heat transfer concept on Bakar Batu Papua's culture," in *AIP Conference Proceedings*, 2018, vol. 2014, no. 1, p. 20133.
- [16] I. R. M. Association, *STEM Education: Concepts, Methodologies, Tools, and Applications*. IGI Global, 2014.
- [17] J. Junaidi, A. Gani, and M. Mursal, "Model Virtual Laboratory Berbasis Inkuiri untuk Meningkatkan Keterampilan Generik Sains Siswa MA," *J. Pendidik. Sains Indones. (Indonesian J. Sci. Educ.*, vol. 4, no. 2, pp. 130–136, 2016.
- [18] H. Saputra, T. M. R. Al Auwal, and D. Mustika, "Pembelajaran Inkuiri Berbasis Virtual Laboratory Untuk Meningkatkan Kemampuan Literasi Sains Mahasiswa Calon Guru Pendidikan Fisika Universitas Samudra," *J. IPA Pembelajaran IPA*, vol. 1, no. 2, pp. 143–148, 2017, doi: 10.24815/jipi.v1i2.9688.
- [19] M. Abou Faour and Z. Ayoubi, "The effect of using virtual laboratory on grade 10 students' conceptual understanding and their attitudes towards physics," *J. Educ. Sci. Environ. Heal.*, vol. 4, no. 1, pp. 54–68, 2017.
- [20] R. G. T. Kusumah, "Peningkatan Kemampuan Berfikir Kritis Mahasiswa Tadris IPA Melalui



- Pendekatan Saintifik Pada Mata kuliah IPA Terpadu,” *IJIS Edu Indones. J. Integr. Sci. Educ.*, vol. 1, no. 1, p. 71, 2019, doi: 10.29300/ijisedu.v1i1.1762.
- [21] I. S. B. Budiarti, S. Suparmi, S. Sarwanto, H. Harjana, and V. Viyanti, “Stimulating Students’ Higher-Order Thinking Skills on Heat and Temperature Concepts,” *J. Pembelajaran Fis.*, vol. 7, no. 2, pp. 103–112, 2019.
- [22] T. M. T. Soh, N. M. Arsad, and K. Osman, “The relationship of 21st century skills on students’ attitude and perception towards physics,” *Procedia-Social Behav. Sci.*, vol. 7, pp. 546–554, 2010.
- [23] R. Bohmer, J. Shand, D. Allwood, A. Wragg, and J. Mountford, “Learning systems: Managing uncertainty in the new normal of COVID-19,” *NEJM Catal. Innov. Care Deliv.*, vol. 1, no. 4, 2020.
- [24] B. Sus, N. Tmienova, I. Revenchuk, and V. Vialkova, “Development of virtual laboratory works for technical and computer sciences,” in *International Conference on Information and Software Technologies*, 2019, pp. 383–394.
- [25] I. D. Wahyono, H. Putranto, D. Saryono, and K. Asfani, “Development of a Personalized Virtual Laboratory Using Artificial Intelligent,” in *International Conference on Learning Innovation 2019 (ICLI 2019)*, 2020, pp. 101–107.
- [26] G. Gunawan, A. Harjono, H. Hermansyah, and L. Herayanti, “GUIDED INQUIRY MODEL THROUGH VIRTUAL LABORATORY TO ENHANCE STUDENTS’ SCIENCE PROCESS SKILLS ON HEAT CONCEPT,” *J. Cakrawala Pendidik.*, vol. 38, no. 2, pp. 259–268, 2019.
- [27] T. Wiedmann, “An input–output virtual laboratory in practice–survey of uptake, usage and applications of the first operational IELab,” *Econ. Syst. Res.*, vol. 29, no. 2, pp. 296–312, 2017.
- [28] M. de T. Durand, C. B. A. Restini, A. C. D. Wolff, M. Faria Jr, L. B. Couto, and R. B. Bestetti, “Students’ perception of animal or virtual laboratory in physiology practical classes in PBL medical hybrid curriculum,” *Adv. Physiol. Educ.*, vol. 43, no. 4, pp. 451–457, 2019.
- [29] H.-T. Hou and Y.-C. Lin, “The development and evaluation of an educational game integrated with augmented reality and virtual laboratory for chemistry experiment learning,” in *2017 6th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI)*, 2017, pp. 1005–1006.
- [30] H. Zhang, M. Diehl, F. Roters, and D. Raabe, “A virtual laboratory using high resolution crystal plasticity simulations to determine the initial yield surface for sheet metal forming operations,” *Int. J. Plast.*, vol. 80, pp. 111–138, 2016.
- [31] M. M. Turner, “Computer Simulation in Low-Temperature Plasma Physics: Future Challenges,” *Plasma Process. Polym.*, vol. 14, no. 1–2, p. 1600121, 2017.
- [32] M. P. Allen and D. J. Tildesley, *Computer simulation of liquids*. Oxford university press, 2017.
- [33] R. V. Davydov and V. I. Antonov, “Equation of state for computer simulation of metal ablation by femtosecond laser pulses,” in *Journal of Physics: Conference Series*, 2017, vol. 929, no. 1, p. 12040.
- [34] B. Shrestha and O.-D. Baik, “Multi-physics computer simulation of radio frequency heating to control pest insects in stored-wheat,” *Eng. Agric. Environ. Food*, vol. 12, no. 1, pp. 71–80, 2019.
- [35] R. Perdana, R. Yani, J. Jumadi, and D. Rosana, “Assessing Students’ Digital Literacy Skill in Senior High School Yogyakarta,” *JPI (Jurnal Pendidik. Indones.)*, vol. 8, no. 2, pp. 169–177, 2019.
- [36] D. Bogusevski, C. Muntean, and G.-M. Muntean, “Teaching and learning physics using 3D virtual learning environment: A case study of combined virtual reality and virtual laboratory in secondary school,” *J. Comput. Math. Sci. Teach.*, vol. 39, no. 1, pp. 5–18, 2020.
- [37] N. R. Herga, B. Čagran, and D. Dinevski, “Virtual laboratory in the role of dynamic visualisation for better understanding of chemistry in primary school,” *Eurasia J. Math. Sci. Technol. Educ.*, vol. 12, no. 3, pp. 593–608, 2016.
- [38] M. Bernard, P. Akbar, A. Ansori, and G. Filiestianto, “Improve the ability of understanding mathematics and confidence of elementary school students with a contextual approach using VBA learning media for Microsoft Excel,” in *Journal of Physics: Conference Series*, 2019, vol. 1318, no. 1, p. 12035.
- [39] R. Perdana, A. Wahyu, and H. Kuswanto, “Simulation using VBA in Microsoft Excel to Enhance Pre-service Physics Teachers’ Motivation,” *Int. J. Sci. Bus.*, vol. 3, no. 3, pp. 114–123, 2019.
- [40] A. M. Ilmi, Sukarmin, and W. Sunarno, “Development of macro VBA as a TPACK based-physics learning media to improve critical thinking skills,” in *AIP Conference Proceedings*,

- 2019, vol. 2194, no. 1, p. 20040.
- [41] E. Amalya, M. Rahmad, and S. Syahril, "VBA-BASED WAVE VISUALIZATION DESIGN USING MICROSOFT EXCEL AS THE MEDIA FOR LEARNING PHYSICS IN SENIOR HIGH SCHOOL," *J. Geliga Sains J. Pendidik. Fis.*, vol. 5, no. 2, pp. 95–103.
- [42] P. S. S. Paramita, "Media Pembelajaran Menggunakan Spreadsheet Excel Untuk Materi Osilasi Harmonik Teredam," in *PROSIDING: Seminar Nasional Fisika dan Pendidikan Fisika*, 2015, vol. 6, no. 5.
- [43] S. K. Katoch, "Modeling and Simulating Radioactivity in the Physics Laboratory of Under-Graduate Students," vol. 12, no. 2, pp. 58–63, 2020, doi: 10.9790/4861-1202025863.
- [44] H. E. Kurniawan, "Pengembangan Perangkat Pembelajaran Ipa Smp Berbasis Problem Based Learning Pada Materi Getaran Dan Gelombang," *J. Pendidik. Fis. dan Keilmuan*, vol. 2, no. 1, p. 16, 2016, doi: 10.25273/jpfk.v2i1.1134.
- [45] H. Yuliani, "Keterampilan Berpikir Kreatif Pada Siswa Sekolah Menengah Di Palangka Raya Menggunakan Pendekatan Saintifik," *J. Pendidik. Fis. dan Keilmuan*, vol. 3, no. 1, p. 48, 2017, doi: 10.25273/jpfk.v3i1.1134.
- [46] S. Chotimah, M. Bernard, and S. M. Wulandari, "Contextual approach using VBA learning media to improve students' mathematical displacement and disposition ability," *J. Phys. Conf. Ser.*, vol. 948, no. 1, 2018, doi: 10.1088/1742-6596/948/1/012025.
- [47] Y. Fitriyani, I. Fauzi, and M. Z. Sari, "Motivasi Belajar Mahasiswa Pada Pembelajaran Daring Selama Pandemi Covid-19," *J. Kependidikan J. Has. Penelit. dan Kaji. Kepustakaan di Bid. Pendidikan, Pengajaran dan Pembelajaran*, vol. 6, no. 2, pp. 165–175, 2020.
- [48] J. Jailani, S. Sugiman, and E. Apino, "Implementing the problem-based learning in order to improve the students' HOTS and characters," *J. Ris. Pendidik. Mat.*, vol. 4, no. 2, pp. 247–259, 2017.
- [49] R. Perdana, A. Wahyu, and H. Kuswanto, "Simulation using VBA in Microsoft Excel to Enhance Pre-service Physics Teachers' Motivation," *Int. J. Sci. Bus.*, vol. 3, no. 3, pp. 114–123, 2019, doi: 10.5281/zenodo.2649953.
- [50] Z. Zaleha, A. Samsudin, and M. G. Nugraha, "Pengembangan Instrumen Tes Diagnostik VCCI Bentuk Four-Tier Test pada Konsep Getaran," *J. Pendidik. Fis. dan Keilmuan*, vol. 3, no. 1, p. 36, 2017, doi: 10.25273/jpfk.v3i1.980.
- [51] G. Rahayu, H. Arga, D. Altaftazani, and M. Bernard, "Effect of VBA Learning Media to Improve Students Decision Making Skill of Elementary School," vol. 370, pp. 42–46, 2019, doi: 10.2991/adics-elssh-19.2019.10.
- [52] A. Rukajat, *Pendekatan Penelitian Kuantitatif: Quantitative Research Approach*. Deepublish, 2018.
- [53] J. Fernandez-Rio, N. Sanz, J. Fernandez-Cando, and L. Santos, "Impact of a sustained Cooperative Learning intervention on student motivation," *Phys. Educ. Sport Pedagog.*, vol. 22, no. 1, pp. 89–105, 2017, doi: 10.1080/17408989.2015.1123238.
- [54] Z. V. Kareth, K. Dahlan, M. Akbar, and O. Togibasa, "Harmonic Oscillation Characteristic using Visual Basic Application," *J. Phys. Conf. Ser.*, vol. 1028, no. 1, pp. 0–5, 2018, doi: 10.1088/1742-6596/1028/1/012046.
- [55] D. M. Fajar, N. Kurniasih, and Khairurrijal, "Simulation of Torricelli Effluent Flow by Using Visual Basic for Application (VBA) on Microsoft Excel," *Proc. 2014 Int. Conf. Adv. Educ. Technol.*, vol. 11, no. Icaet, pp. 158–161, 2015, doi: 10.2991/icaet-14.2014.39.
- [56] G. D. S. Rahayu, M. Bernard, D. Mulyono, and S. Rabbani, "VBA media development for microsoft excel against students' mathematical problem solving," *J. Phys. Conf. Ser.*, vol. 1657, no. 1, 2020, doi: 10.1088/1742-6596/1657/1/012079.
- [57] C. Umamah and H. J. Andi, "Pengaruh Model Project Based Learning Terhadap Keterampilan Berpikir Kreatif Dalam Pembelajaran Fisika Terapan," *J. Penelit. Pembelajaran Fis.*, vol. 10, no. 1, p. 70, 2019, doi: 10.26877/jp2f.v10i1.3507.
- [58] F. HAN and F. KANG, "Exploitation and Research on 3D Digital Modeling of Track Structure Based on VBA," vol. 72, pp. 424–427, 2017, doi: 10.2991/aece-16.2017.93.