ANALYSIS OF CLOUD COMPUTING SERVER NEEDS IN SUPPORTING COMPUTATIONAL PHYSICS LECTURES

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ABSTRAK

Telah dilakukan penelitian mengenai kebutuhan komputasi awan dalam mendukung perkuliahan Fisika Komputasi di Universitas Bengkulu. Subjek penelitian ini adalah mahasiswa yang mengambil mata kuliah fisika komputasi dan algoritma. Penelitian ini bertujuan untuk mengetahui urgensi implementasi komputasi awan dalam mendukung proses pembelajaran. Dalam penelitian ini, kuesioner digunakan untuk mengumpulkan data yang termasuk jenis data kualitatif. Statistik deskriptif digunakan untuk mendeskripsikan tanggapan dan mengidentifikasi tren utama dalam persepsi mahasiswa mengenai efektivitas dan perlunya penggunaan alat komputasi awan dalam tugas-tugas mahasiswa. Hasil dari penelitian ini menunjukkan bahwa 30% mahasiswa tidak memiliki perangkat yang memenuhi syarat untuk menjalankan pemrograman numerik. Di sisi lain, sebagian besar mahasiswa memiliki perangkat Android, dan ini berarti ada potensi besar bagi solusi komputasi awan untuk digunakan dalam upaya membuat mereka menjadi pelajar yang lebih baik. Hal penting kedua yang telah ditetapkan oleh penelitian ini adalah bahwa sebagian besar siswa menunjukkan ketertarikan pada penggunaan aplikasi berbasis awan, yang berarti ada kebutuhan akan sumber daya yang dapat digunakan untuk menjembatani kesenjangan dalam mengakses teknologi. Hal ini menunjukkan bahwa ada preferensi yang kuat dari para siswa untuk sumber daya berbasis awan untuk membantu dalam kolaborasi dan aksesibilitas tugas-tugas kuliah.

Kata Kunci : *Komputasi awan, Pemrograman python, Komputasi fisika*

ABSTRACT

Study of cloud computing needs in supporting Computational Physics Lectures at Bengkulu University has been conducted. The subjects of this study were students who studied computational physics and algorithms. This research aims to examine the urgency of cloud computing implementation in supporting the learning process. In this research, questionnaires were used to collect the data, which included qualitative data types. Descriptive statistics were used in describing the responses and in identifying key trends in the students' perceptions concerning the effectiveness and the necessity of cloud computing tool usage in student coursework. The result of this research showed that 30% of the students did not possess qualified devices to run numerical programming. On the other hand, most of the students have Android devices, and this means that there is a great potential for cloud computing solutions to be used in pursuit of making them better learners. The second important thing that this study has established is that most of the students showed interest in the use of cloud-based applications, which means there is a need for the resources that can be used in bridging the gap to access technologies. That suggests that there is a strong preference on the part of the students for cloud-based resources to help in collaboration and accessibility of coursework.

Keywords*: Cloud Computing, Python Programming, Computational Physics.*

I INTRODUCTION

Computational physics is a scientific area that embodies the principles of physics with methods of computer science (1). In general, it aims to solve complicated physics problems that, due to their nature, cannot be solved by traditional analytical techniques. Computational physics is designed to provide such tools and techniques as can help the researcher in modeling physical phenomena, analyzing experimental results, and predicting the behavior of physical systems under a variety of conditions. This capability also allows scholars to explore situations that are impossible to realize directly by experimentation and, indirectly, saves time and resources (2). In the field of education itself, computational physics has emerged as an integral component of scientific curricula, particularly in the streams of physics and engineering. The teaching of computational physics introduces the students not only to basic aspects of physics but also develops the analytical and programming skills highly valued in today's digital environment (3). Through the utilization of modeling and simulation techniques, students are able to visualize and grasp intricate physical phenomena with greater clarity. Moreover, computational physics aids in the use of inquiry-oriented teaching practices, enabling students to get involved in virtual experiments, thus enriching their conceptual knowledge and their ability to tackle problems. Apart from developing the above characteristics, the integration of computational physics into educational curricula also develops inter-disciplinary collaboration and, hence, strengthens the inter-relationships among physics, mathematics, and computer science necessary to produce competent professionals in the years to come (4).

Despite the importance of computing courses in physics, a number of issues create obstacles to learning. First and foremost comes the limited availability of suitable hardware and software (5). Most institutions are not in a position to provide high-performance computers or special software licenses that are needed in order to be able to simulate and model complex physical phenomena (6). In addition, programming is often a difficult skill for those without the computer science domain's background. It takes a lot of time and effort to learn the programming languages, such as Python or C++, which it is possible to spend less time learning the physics. Additionally, it is worth considering the already full curriculum, learning the physics computing puts more workload on students. These all pose challenges to which creative strategies and strong institutional support are needed to overcome such constraints and allow the attainment of objectives apparent in physics computing courses.

One feasible solution to overcome these challenges in computational physics lectures is the adoption of cloud computing technology (7). Cloud computing allows data and applications to be stored, processed, and accessed over the internet without requiring expensive physical infrastructure. For physics education, it opens up easy and economical access to advanced physics computing software together with high-performance computing resources. Students are able to conduct intricate simulations and modeling through computers that possess minimal specifications, as the computational processes are executed on cloud servers. Furthermore, cloud computing facilitates efficient online collaboration, enabling both students and lecturers to exchange data, programs, and simulation outcomes in real-time (8). Consequently, cloud computing not only diminishes technical and financial barriers but also enhances flexibility and accessibility in the learning of physics computing. Cloud computing can potentially bring about greater improvements in learning while providing expanded opportunities for students to develop computational skills, particularly in physics education.

Another cloud computing platform of relevance to the study of computational physics is Google Colab. It works within a cloud-based framework that allows execution of Python directly through a web browser, eliminating the need for additional software installations (9). The ease with which it can be used in education is further emphasized by the freely available programming interface, free-of-charge access to it, and integration with Google Drive for handling data. It has the support for many scientific libraries and computational resources such as NumPy, SciPy, Matplotlib, and TensorFlow. Especially helpful to make physics simulation and models. Because of Google Colab, one can easily share the notebook with an instructor or colleague, and further collaboration in shared notebooks can be done easily. Free GPUs and TPUs here reduce processing time for data manipulation and simulation very significantly. Thus, Google Colab is a very powerful and practical alternative of deploying cloud computing in the area of physics computing, as it works to avoid many of the technical and cost constraints imposed on educational establishments.

According to the syllabus in the Department of Physics Education at the University of Bengkulu, computational physics is one of the subjects that must be taken by students. This course is offered to 3rd semester students who have taken basic physics and mathematics for physics, which are prerequisite lectures for physics computing lectures. With a weight of 3 credits, students are expected to understand the basic concepts of computing and its application in solving complex physics problems. There are 2 programming languages taught in this course, namely Python 3 and MATLAB, each of which has advantages in data analysis and numerical simulation. This course discusses basic concepts in programming such as the introduction of variables, data types, logical relationships, math libraries, control flow, and data representation techniques. Furthermore, this course also discusses advanced programming concepts such as curve fitting techniques, the concept of fast fourier transform, as well as numerical methods for solving differential equations and the concept of finite difference. Students will also be given a challenging final project to apply all the knowledge gained in the analysis of real physics experimental data. In the learning activities for this course, instructors generally use Python IDE or Jupyter Lab, which are installed directly on each computer device. In the installation process, Anaconda packages are generally used to set up the working environment, which involves configuration through the terminal console that can be time-consuming and quite complicated to follow. One viable solution to address all of that is to switch to using cloud computing services that do not require overly complicated technical setups for students to follow. Therefore, in this research, the author will focus on analyzing the need for the use of cloud computing to support academic activities.

II RESEARCH METHOD

This study was conducted at the Department of Physics Education, Bengkulu University in June-August 2024. Using qualitative method, data were collected using questionnaire. The questionnaire was created with the help of the google form platform which was distributed to students in the Physics Education department of Bengkulu University. The questionnaire consisted of 13 closed questions classified into two main points, namely regarding demographics and questions related to cloud computing. The list of questions from the questionnaire is outlined as in Table 1. The first part of the questionnaire aims to determine the demographics and initial state of the students. In this section, the questions were designed as a closed questionnaire with nominal data type. The second part of the questionnaire, with ordinal data type, aims to determine students' response to the application of cloud computing in computational physics lectures.

Table 1. Indicators of cloud computing needs in computational physics lectures.

Questions	Rating scale
A. Demographics	
1. Gender	[ ]Male; [ ]Female
2. Owns a proper computational device (PC/laptop)?	[ ]Yes; [ ]No
3. Owns android/tablet like device	[ ]Yes; [ ]No
4. Have you ever used cloud service before (e.g., Google Drive, Dropbox) for academic purposes?	[ ]Yes; [ ]No
5. Knowledge about cloud computing	[ ]Yes; [ ]No
6. I have access to internet in almost everywhere	[ ]Yes; [ ]No
B. Needs and Preferences Related to Cloud Computing	
1. It's easy for me to deploy programming environment locally on my device by myself	[1]Strongly disagree, [2]Disagree, [3]Neutral, [4]Agree, [5]Strongly agree
2. My device could run programming environment seamlessly	
3. I prefer use lab computer instead my own device to run computational physics program	
4. I prefer online service (cloud computing) than run computational physics simulation locally	
5. It's easy for me to open cloud computing services in my browser	
6. Cloud computing services enhance overall efficiency.	
7. I'd rather use cloud computing services to finish my assignment	

Data analysis used descriptive statistics to describe the tendency of student responses to question options on the questionnaire. Mean, mode, and standard deviation were calculated from the data to describe students' responses to the question options. Mean shows the tendency of students. The greater the mean value, the greater the tendency of students to agree with the given statement. In addition, frequency and standard deviation analysis were also conducted to see the distribution of answers and identify patterns that might appear in student responses. The calculation of the standard deviation is also done to understand how far the students' answers vary from the mean value, which can provide deeper insight into the consistency or uncertainty in their responses.

III RESULT AND DISCUSSION

3.1 Demographics of Respondents

In this study, empirical data was obtained from questionnaires and interviews with 70 students who were taking computational physics lectures. The demographics of the respondents consisted of 17% male students and 83% female students as shown in Figure 1. In these demographics it is clear that the female gender is more dominant than the male gender. Some research has mentioned that men are still more dominant in the development of technology utilization (10). This gender imbalance may provide different perspectives on the needs and challenges in the use of technology which in this case is the installation and use of a programming environment in support of computational physics lectures.

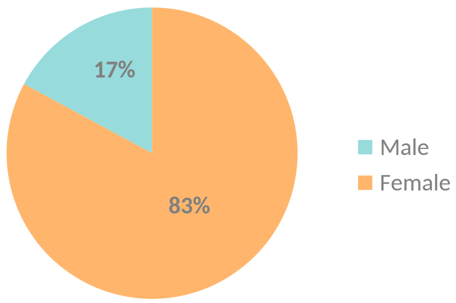

Figure 1. Gender distribution of respondents

Furthermore, the results obtained from the questionnaire showed that among the 70 participants, 30% did not own a personal computing device, such as a desktop or laptop computer, as illustrated in Figure 2. This finding is particularly important, given that computing devices are an essential component in facilitating computational physics instruction. Lack of access to personal computing devices can be a considerable barrier, especially in courses that require high computation, such as computational physics. Although in its implementation, physics computing

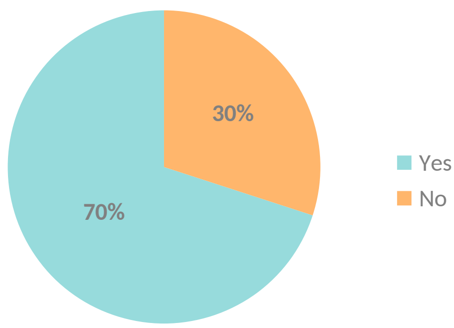

Figure 2. Demographics of students who own computing devices

lectures are held in the computer lab, it is not enough to support student needs. However, other data from the questionnaire showed that 100% of the participants owned a secondary device, specifically an Android smartphone. This situation provides an opportunity for students to be able to access cloud-based services (11). Thus, the development of user-friendly cloud-based services for smartphones can be one of the effective solutions in overcoming the limited access of personal computing devices.

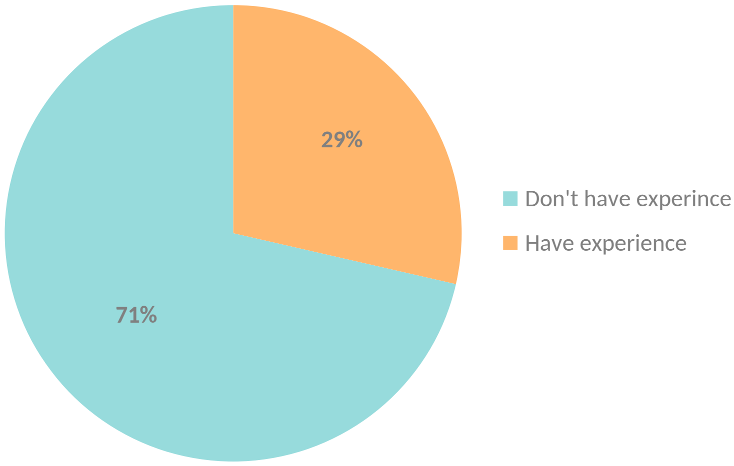

Figure 3. The comprehension of Cloud Computing technology among students.

The concept of cloud-based service is not so relatively new for students. Though survey results, as depicted in Figure 3, said the opposite-that students did not know much about cloud computing technology, they are already used to conducting their activities with cloud services like Google Workplace, Microsoft 365, Canva, and others. This is evident from the survey results, as it said that 100% of the student respondents had used these cloud services. With the basic knowledge that these students already have on the usage of these cloud services, it will widen the avenues for adapting cloud computing platforms that can support computational physics lectures so that students who do not have personal computing devices will also have equal access to learning inside and outside the classroom (12). Moreover, the integration of such technologies will enable the lecturers to interact with the students in a way that more dynamic learning can take place, being responsive to individual needs.

The opportunity to adapt teaching using cloud computing is also further strengthened by the fact that students don't have difficulties accessing the internet. Respondent data shows that 100% of students have adequate internet access, so they can utilize various online resources to support the teaching and learning process wherever they are. With adequate internet access, technical constraints such as hardware limitations can be minimized. Adapting teaching to cloud computing will not only improve learning efficiency but also prepare students to enter an increasingly technology-based workforce (13). Therefore, the fact that all respondents have internet access almost anywhere is a strong foundation for implementing cloud computing in computational physics lectures.

3.2 Students' Cloud Computing Preference

Students' perceptions and responses to the use of cloud computing in computational physics lectures were obtained through questionnaire data designed using a Likert scale. There are 7 main indicators asked to describe student preferences. The distribution of each indicator is shown as in Table 2.

Table 2. Frequency distribution data of student responses to the use of cloud computing in computational physics lectures

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
(Q1) It's easy for me to deploy programming environment locally on my device by myself	44%	30%	26%	0%	0%
(Q2) My device could run programming environment seamlessly	46%	11%	31%	11%	0%
(Q3) I prefer use lab computer instead my own device to run computational physics program	0%	0%	26%	29%	46%
(Q4) I prefer online service (cloud computing) than run computational physics simulation locally	0%	0%	6%	43%	51%
(Q5) It's easy for me to open cloud computing services in my browser	0%	0%	19%	41%	40%
(Q6) Cloud computing services enhance overall efficiency.	0%	0%	0%	61%	39%
(Q7) I'd rather use cloud computing services to finish my assignment	0%	0%	0%	61%	39%

Based on the data obtained, there are 2 groups of statements that have different polarizations. Statements Q1 and Q2 show negative responses from students, which means that respondents, in this case students, do not agree with the statements given. As shown in Table 2, statements Q1 and Q2 are related to the installation of programming software locally on a personal computer/laptop and the user experience when running the program. This is understandable because the installation process for programming software often requires complex configurations and can cause confusion for less experienced users. This is also coupled with varying computer specs among students, which may not meet the minimum requirements to run the software properly. In contrast to statements Q1 and Q2, statements Q3-Q7 show a positive response which means that students agree with the statements given. As shown in Figure 4, the distribution of responses from the survey is clustered to the right (Positive side).

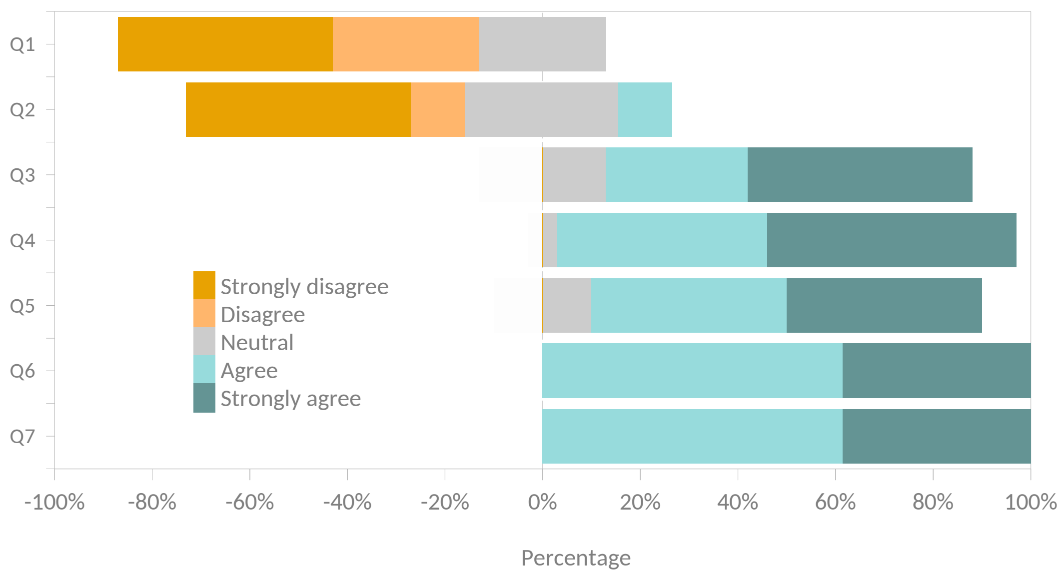

Figure 4. Likert graph of student responses to cloud computing

In addition to the perspective provided by the distribution illustrated in Error: Reference source not found, the responses of students regarding the implementation of cloud computing in lectures can also be analyzed through the outcomes of the descriptive analysis of the data collected, as demonstrated in Table 3. Judging from the average data from each indicator, it shows a negative trend in indicators Q1 and Q2 and positive in indicators Q3, Q4, Q5, Q6, and Q7. Statement Q1 with an average value of 1.81 indicates that students do not agree with statement Q1 or find it difficult to carry out the programming software installation process. The average results on statement Q2 show that the programming software does not run well on the devices they have. This is because the specs of the computing devices they have are relatively low, so it takes a long time to wait just to open or run a few lines of programming commands. Students also mostly agree that they prefer to use laboratory computers in running programs rather than using their own devices because the performance of laboratory devices is more optimal and supports a more effective learning process. This is indicated by the average value of 4.2 in the Q3 statement indicator.

Table 3. Descriptive statistics of all indicators of student responses to cloud computing

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
N	70	70	70	70	70	70	70
Mean	1.81	2.09	4.20	4.46	4.21	4.39	4.39
Mode	1.00	1.00	5.00	5.00	4.00	4.00	4.00
Standard deviation	0.822	1.11	0.827	0.606	0.740	0.490	0.490

Indicator statement Q4 has an average value of 4.46 with mode 5, which states that most students strongly agree with the statement that if possible they prefer to do work via a browser or in other words via the cloud services. This is also supported by the fact that it is very easy for them to access cloud computing via a browser rather than having to manually setup on a local computer. Cloud computing does have advantages over local computers, such as flexibility in data storage, the ability to collaborate in real-time, scalability, and non-dependence on specs from local devices (14). From the perception of efficiency in learning, almost all respondents agree that the use of cloud computing in lectures increases the efficiency and quality of their learning. this is indicated by the average results of indicators Q6 and Q7 of 4.39 which are included in the domain of agree and strongly agree.

Based on data analysis of all indicators, it is clear that the use of cloud computing in computational physics lectures is needed. The survey results show that students agree with the use of cloud computing in computational physics lectures. Although cloud computing offers many advantages in supporting learning, this technology also has some disadvantages that need to be considered. One of the main disadvantages is the high dependency on internet connection, which can disrupt access to cloud services and data if the internet is slow or unstable. In addition, storing data on third-party servers can pose security and privacy risks, as sensitive data becomes vulnerable to unauthorized access and cyberattacks (15). The long-term cost of using cloud computing can also be expensive, especially with subscription fees and additional usage increasing over time. Educational institutions may face limitations in the control and customization of cloud services, as well as significant dependence on the service provider, which may result in operational disruptions in the event of problems with the provider (16). In addition, cloud service performance can be unstable due to sharing resources with other users, and institutions must ensure compliance with regulations and laws regarding data storage, which can be challenging if the cloud service is located in a different jurisdiction (17). Understanding these drawbacks is important for developing the right strategy to adopt cloud computing effectively.

IV CONCLUSION

This research aims to conduct a needs study of the use of cloud computing in physics computing lectures using questionnaire data on 70 respondents of students who take physics computing lectures at the physics education department of Bengkulu University. Based on the results of the needs study, several problems were obtained including 1) There are 30% of students who take physics computing courses who do not have a personal computer or laptop, 2) Students have difficulty in setting up programming software on their own devices, 3) Most student computing devices are below the specified spec so that programming software sometimes runs less than optimal, 4) Students strongly agree with the application of a cloud-based system that can facilitate their learning activities without worrying about the spec of the devices they have. Based on the above findings, it is highly recommended to use a cloud computing system in supporting physics computing lectures.

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