Development of an E-learning Platform Utilizing Virtual DOM and Base64 to Limit Internet Data Charges Incurred for the Department of Education Region III, Division of Pampanga.

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Abstract

The COVID-19 pandemic has managed to bring the entire world to its knees. It has struck the Philippines and exposed the Department of Education's dilemma in implementing technological capabilities. Although the education sector has adopted the use of Learning Management Systems, the Department of Education has trailed in this direction since many of the public-school students cannot easily cope up with such technological advancement considering their financial capabilities. As a matter of fact, the department opted to implement modular classes through distribution of self-learning kits, citing the impossibility of conducting classes using internet now. This research focuses on assessing the capabilities of common e-Learning platforms used by public schools in the Department of Education, Region III, Division of Pampanga. It also focuses in developing a tailored-fit platform to reduce the data charges incurred by stakeholders and base the features according to the requirements and needs of the Department of Education, Region III, Division of Pampanga. According to the results of this study, the utilization of Virtual DOM and Base64 in the tailored-fit platform has significantly reduced the data charges incurred compared to using common e-Learning Platforms.

Keywords
e-Learning; Learning Management System; K-12 Computerization; e-Quiz; Online Learning Management.

1. Introduction
People all over the world are acclimating through the new ways of how to do things because it has been over a century since the last pandemic, the h1n1. At the present time, the populace is facing an equally devastating pandemic brought about by COVID-19. The Philippines has faced an economic meltdown during the first quarter of 2020. The education sector, under the supervision of the Department of Education, was one of the most affected by the pandemic. As a matter of fact, one of the considerations during the early phases of the pandemic was an academic freeze.

Considering the president's directive, to make the Philippines digitally at par with other nations, the Department of Education, headed by Sec. Leonor Magtolis-Briones, began to incorporate technological advancements to its charter through the use of DepEd's LRMDS, DepEd Commons and DepEd LIS even before the pandemic happened. Despite these initiatives, this unexpected phenomenon has shown that these major leap for the Department of Education, in terms of its technological capability may be a little too late. Considering that most of these platforms are not tailored-fit for the existing orders, memoranda and guidelines, the Department of Education has decided to push for modular learning, providing learners with self-learning kits. Majority of the schools that have utilized e-Learning platforms in

their respective countries proved to be beneficial (Voogt et al. 2017). According to researchers Cuisia-Villanueva & Núñez (2020) of the University of the Philippines, thirty-three percent (33%) strongly believe that they have the necessary devices for online classes while the remaining sixty seven percent (67%) agree that they possess the devices required to continue with the e-learning platform. This shows that the device is not the main problem that e-Learning in the Philippines faces. An example of a university that applies and takes advantage of the capabilities of e-Learning is the University of Cordilleras. In partnership with a US-based IT integrator, they have developed eLearning Systems Inc. (ESI). The tools present on the system does not only deliver content-knowledge, it also makes use of the skills to apply such contents. The University of Cordilleras calls it "virtual classroom on a desktop", since each station has a lecturer, audio-visual illustrations, exercises and video.

Several schools in the Philippines have started to adopt e-Learning systems into their curricula due to the pandemic and the attached protocols and guidelines made by the IATF on the suspension of face-to-face classes (Fabito et al. 2020; Baticulon et al. 2021). This has significantly assisted students to access essential information to widen their understanding of certain topics and not just be confined to the four corners of the classroom. The COVID-19 pandemic has made the adoption of new technologies within the classrooms worldwide to intensify. A large number of national educational systems have put up initiatives in order to launch measures in adopting an e-Learning System to enhance the educational experiences of teachers and learners alike (Moodly & Adu, 2014; Voogt et al., 2017; Al-Ohali et al., 2020). Throughout the years of implementing e-Learning systems, specific challenges on relevant case studies have been outlined and documented. The adoption of these systems highlighted specific limitations, challenges and hindrances. These were organized and grouped into six categories: (1) the school, (2) the teacher, (3) the student, (4) the project, (5) technology and (6) research & policy (Bennett, 2017; Al-Ohali et al., 2020). The Department of Education faces several challenges, among which poses the lack of funds, especially considering the financial capabilities of most of the public-school students, to fully implement an online e-Learning System as of the moment. According to an article authored by Abad (2020), the Philippines utilizes the following e-Learning platforms as reported by both teachers and learners alike: Edmodo, Facebook groups and Messenger, Google Classroom, Google Hangouts, Moodle, Schoology, Skype and Zoom. This study aims to assess available e-Learning platforms and determine gaps and areas for improvement to be addressed through the development of an e-Learning platform that adheres to the Department of Education's orders, memoranda, guidelines, and technological capability. It also seeks to lower the data charges incurred when using the e-Learning platforms; determining a user-friendly interface for both learners and teachers; choosing an open-source technology. In doing so, the obstacles, challenges and limitations posed by Al-Ohali et al. in their research will partially be solved considering the targeted hindrances that the Department of Education faces. This study will not only prove beneficial because of the pandemic that the populace is experiencing but also to keep at par with the international community in bringing education a step higher.

1.1 General Objective

The general objective of the study aims to assess the e-Learning platforms' ability to address the needs of stakeholders and to design and develop a platform that uses virtual DOM / base64 to minimize internet data charges.

1.2 Specific Objectives

1. To identify the e-Learning platforms utilized by teachers in the Department of Education, Region III, Division of Pampanga.

2. To evaluate the internet data charges incurred when using the e-Learning platforms.

3. To design and develop a program that utilizes the advantages of Virtual DOM and Base64 in contrast with the regular server-side requests to lessen the data charges incurred.

2. Literature Review

E-learning, also called online learning, is defined as a learning modality that utilizes electronic resources and electronic devices in delivering education. For example, class discussion using online video conference tools such as Google

Meet, Microsoft Teams, Zoom, etc. The adoption of e-learning becomes essential as the society adjusts to the new normal. In the Philippines, Department of Education (DepEd) makes use of LIS, DepEd Commons, LRMDS (Learning Resources Management and Development System) and Google Forms as their online educational platforms. However, these systems are not capable of communicating with each other unlike the platforms or learning management systems (LMS) used by private institutions. Moreover, the online platforms developed by DepEd require large amounts of data that could pose challenges to public school students. One of the challenges is their financial capabilities to cover the cost of internet in accessing these online platforms.

The most common Learning Management Systems include Google Forms, Canvas, Moodle and Schoology. Google Forms is an e-Learning tool developed by Google that can be accessed and utilized for free by anyone with a Google account. Google Forms provides the following features to its users: 1) ease of developing surveys; 2) Creating quizzes; 3) uploading of file; and 4) gather and monitor data in spreadsheet. Another widely used Learning Management System is Canvas. It is developed by Instructure Inc. and is used by universities to virtually access and manage learning materials, student learning and assessment. Its features include: 1) creating and sharing content; 2) collaborative learning tools and communication tools; 3) assessment tools; and 4) monitoring and tracking tools. Moodle is a free and online learning management system by Moodle Pty Ltd that provides educators and learners their e-Learning needs, such as creating private website filled with courses. It has the capability to provide 1) collaborative tools and activities; 2) file management; 3) monitoring and tracking; and 4) administrative features. Schoology is a software produced by PowerSchool Unified ClassroomTM Solution that supports online learning and blended learning environments. Schoology equips teachers and students learning tools to improve delivery of education thru the following features: 1) assessment tools; 2) monitoring tools; and 3) collaborative tools.

These existing platforms were used by educational institutions even before the pandemic of 2019. They have been proven to be beneficial to both teachers and students alike and enhances the educational experience (Voogt et al., 2017). They all excel in different aspects but the key factor that hinders the Department of Education Region III in implementing these e-Learning platforms is the requirement for internet which includes charges that may not be economically viable for public-school students. Previously developed platforms such as Google Forms, Google Classroom, Moodle, Canvas and other well-known Learning Management Systems cannot run locally on a machine. Internet is not free and for a third-world country such as the Philippines; data charges are one of the top challenges that Filipino public-students face when utilizing an e-Learning system. To answer questions on how much internet data charges cost and what e-Learning platform in terms of data usage is best to be utilized, this paper shows how data charges are computed by some of the popular ISPs in the Philippines. PLDT and its subsidiaries, and Smart Communications, Inc. computes data web browsing to be at least 240MB per hour while Globe Telecom Inc., ranges it from 200MB to 400MB per hour. Video streaming in 480p and 1080p resolution using PLDT / Smart eats about 480MB to 3500MB per hour respectively. Globe charges 264MB to 1.65GB per hour respectively. Sharing photos using either of the ISPs consumes 2MB to 5MB depending on the resolution of the photo. This information shows that the possibility of adopting an e-Learning platform for the Department of Education Region III becomes plausible with minor tweaks on how e-Learning platforms communicate backend to lessen some of the data charges. Furthermore, the adaptation of the e-Learning platform carries several advantages.

The use of e-Learning Systems has been greatly utilized since 2011. Since then, it has evolved and addressed common issues that rose during its first introduction. Below are some of the advantages in utilizing an e-Learning System to strengthen teacher and learner relationship and assist the learning process. Several e-learning open-source software are available and adopting this software can reduce the cost of high-priced systems. Because of a large open-source community, bugs and errors can be quickly addressed. Another advantage of an open-source software is that it can be easily modified to suit what the institution needs without sacrificing the quality and security of the software (Obeidallah and Shdaifat, 2020). E-assessments such as online quizzes have been part of the e-Learning platforms; these have been used to evaluate the learners' achievements in an online course. Such tools support the educational process through the facilitation of virtually keeping records. They promote lesser costs, multiple sets and can be checked instantaneously (Sindre and Vegendla, 2015). The use of an e-Learning System creates an online connection between the teachers and the learners over the internet which supports and enhances the learning process (Yulianandra et al., 2017.; Baleghi-Zadeh et al., 2017; Anggrainingsih et al., 2016). It must be noted that three main tools must be present to maximize the advantages. According to Wichadee (2015) they are: communication tool (e.g. chat functions, note/comment functions, announcement boards, and forums); a study skill tool, used to create materials (e.g. quizzes, lectures and notes) and; a productivity tool. According to the research of Obeidallah and Shdaifat, (2020) e-assessment tools can measure the reliability, quality and validity of a given topic; it provides graphs and statistics to easily see

what needs to be adjusted and were accomplished; it also provides feedback to learners, check and measure their efficiency in the topics provided. Alajbeg et al. (2017) says that the e-assessment tools that are incorporated on e-learning systems reduce the efforts of teachers in their quiz or assessment preparations. It also helps them check and record instantaneously. The use of this tool minimizes the chance of having an inaccurate evaluation.

3. Methods

According to Toth-Stub (2020), the use of e-Learning was approximately growing at a rate of 15.4% yearly in educational institutions across the globe without any pressure or uncertainties to both the students and the institution. Due to the pandemic, the situation has changed dramatically and the need for e-Learning has turned into almost a necessity. Over 60% of educational institutions started to provide access to their services online to minimize the impacts of COVID-19 and to adhere to the imposed global restrictions (Alqahtani and Rajkhan, 2020).

The research design of this study was mixed method. Descriptive method was used in terms of the identification, assessment, and evaluation of the e-Learning platforms. Agile development methodology was used for the development of the iterated platform.

3.1. Study Design

The descriptive research design was used in this study in so far as the identification, assessment and evaluation of the e-Learning platforms processes are involved. This method aimed to describe the population, situation, and phenomenon in an accurate and systematic manner. It can answer what, where when and how of this study. The descriptive research design was chosen due to its applicability of use in a wide variety of research methods to investigate and be able to manipulate one or more variables. This research design is suitable when the study's aim is to identify characteristics, frequencies, trends, and categories.

The other method was Agile development, this was used in creating the e-Learning platform that is suited to the rules and guidelines issued by the Department of Education. The Agile method was chosen because of its ability to create and respond to changes. The Department of Education continuously updates its rules and guidelines to keep up and address the ever-changing needs of its stakeholders. Agile development methodology also proves to be beneficial because it can succeed even on uncertain and turbulent environments (Agile Alliance, n.d.).

3.2. Study Participants

This research focuses on trying to assess the best platform to be adopted by public schools in the Department of Education, Region III, Division of Pampanga. It also looks at possibility of reducing the data charges incurred when using an e-Learning Management System and tailor-fitting the same based on the requirements and needs of the Department of Education, Region III, Division of Pampanga. Ergo, study participants will be teachers and learners from senior high school under the Department of Education, Region III, Division of Pampanga.

The Department of Education, Region III, Division of Pampanga is composed of five hundred and fifty-three (553) public schools and one hundred and eighty-six (186) private schools. This study focuses on the public schools only. As per the Learner Information System of the department, there are about three thousand (3,000) senior high school and junior high school students and about eight hundred (500) high school teachers in the selected clusters. Following Raosoft's system, an innovative survey software programs for information gathering and analysis for statistical computation, the proponent shall need the following

If 50% of all the target in a population of 3500 stakeholders find the system to be useful, applicable and incurs less data, and if you were to repeat the survey of 347 people ("Did you find the system to be useful, applicable and incurs less data?") many times, then 95% of the time, your survey would find that between 45% and 55% of the people in your sample answered "Yes". The remaining 5% of the time, or for 1 in 20 survey questions, you would expect the survey response to more than the margin of error away from the true answer. In terms of the numbers selected, the sample size n and margin of error E are given by

$$x = Z(c/100)2r(100-r)$$
$$n = N\,x/((N-1)E2 + x)$$
$$E = Sqrt[(N - n)x/n(N-1)]$$

where N is the population size, r is the fraction of responses that you are interested in, and Z(c/100) is the critical value for the confidence level c. This study accepts a margin of error of 5%, needs a confidence level of 95%, a population size of 3,500 including teachers and learners, and 50% response distribution. The formula suggests that there should be at least 347 respondents for the survey.

3.3. (Specific Procedures Based on Study Objectives)

3.3.1. Ethical Considerations

The descriptive part of this research conducted surveys and made use of Google Forms to facilitate an online process to adhere to the NIATF and local IATF guidelines. It is also ensured by the proponent that the data collected was treated with utmost confidentiality and in accordance with the guidelines set by the Department of Education and Republic Act 10173 or the Data Privacy Act of 2012.

3.3.2. Identifying and Assessing the Usability and Applicability of the e-Learning Platforms Utilized by Teachers in DepEd Region III, Division of Pampanga

The Department of Education has not made the use of e-Learning platforms mandatory due to the internet data charges they entail. However, some schools, with the consent of parents have made use of e-Learning platforms. The proponent conducted an online survey to identify the different e-Learning platforms being utilized by teachers to help them in the delivery of the teaching and learning process. After having identified the platforms, an assessment was made by the proponent through extensive interviews and direct comparison of the available features to the needs of the Department of Education as indicated on existing DepEd Orders. This helped the proponent identify which features to keep and improve, and which features can be disregarded.

3.3.3. Evaluate the Data Charges Incurred When Using the e-Learning Platforms

The identified platforms went through different manual timed-testing, automated testing, and actual student test to get the average data charges used while using the features of the existing e-Learning platforms. Only the most popular ISPs (PLDT SMART and Globe) were used for testing. Each result was recorded and compared to the LMS that was developed.

3.3.4 Design and Develop a Platform that Lessens Internet Data Charges Incurred

3.4.4.1 Requirements Phase

Following the Agile Development methodology, the proponent collected necessary requirements in this phase before proceeding to the next phase. Collation of DepEd Orders pertaining to the handling of classes during COVID-19 pandemic was used. Surveys were also be utilized to harness some of the best practices used by teachers during this pandemic.

3.4.4.2 Design Phase

Based on the requirements gathered during the first phase, the proponent designed the back end of the proposed system. PHP and MySQL were used for the server-side needs of the system. This is to ensure that no fees shall be required when using the system and to further utilize the availability of support for open-source software. The front end was also designed in this phase following the structure and schema design of the database. The system utilized a liquid design in order to fit to any screen size and resolution of device that the learner is using.

3.4.4.3 Development Phase

This phase was incremental and iterative. This is to allow for “repeating” activities during the development cycle and for potential “revisits”. The proponent developed each part of the system as a module in order to utilize the advantages of a framework which uses controllers, models, and views. The proponent also considered the use of virtual DOM and Base64 in order to reduce the data charges incurred while using e-Learning platforms. Because of being incremental and iterative, the proponent can easily adjust errors and address changes in DepEd policies along the way.

3.4.4.4 Testing Phase

The proponent utilized this phase to catch errors in the system prior to possible deployment. One of the advantages of using agile method is being able to immediately go back to designing phase and development phase if the need arises. The proponent went through the cycle until the system was ready and able to address most of the needs of the Department of Education, Region III, Division of Pampanga.

3.4.4.5 Deployment Phase

The final stage of the agile development method is the deployment. The proponent deployed the system at a live server for a period until pilot runs, and surveys were made by the selected schools in the Division.

4. Results and Discussion

This focuses on the applicability of the developed system for the Department of Education Region III, Division of Pampanga and how internet data charges were lessened during the usage of the developed system compared to the regular e-Learning platforms being utilized before.

Table 1. Demographic Profile of Respondents Based on Grade Level / Position

Grade Level / Position	Frequency (f)	Percentage
Grade 7	27	7.8%
Grade 8	42	12.1%
Grade 9	56	16.1%
Grade 10	60	17.3%
Grade 11	56	16.1%
Grade 12	79	22.8%
Teacher	27	7.8%

As reflected on Table 1, among 347 respondents, 27 were from grade 7, which comprises 7.8%, 42 were from grade 8, which comprises 12.1%, 56 were from grade 9, comprising 16.1%, grade 10 respondents are 60 equivalents to 17.3%, grade 11 respondents were 56 comprising 16.1%, 79 were from grade 12 comprising 22.8%, and finally 27 teachers or about 7.8%.

Table 2. Data Charges Incurred Using the Common e-Learning Platforms

Statements	5	4	3	2	1	Mean	SD	Verbal Interpretation
A.1	159	183	3	2	0	4.44	0.55	high data charges
A.2	136	111	99	1	0	4.10	0.82	high data charges

Based on the data gathered and analyzed as shown on Table 2, respondents claimed that they have accumulated high data charges when using common e-learning platforms to download modules / lessons given by their teachers. It has a mean of 4.44 and a standard deviation of 0.55. Respondents also claimed that they have accumulate high data charges when using common e-learning platforms to accomplish tasks given by their teachers. It has a mean of 4.10 and a standard deviation of 0.82. This indicates that using the traditional or most common e-Learning platforms incur high data charges due to the current rate imposed by internet service providers in the Philippines.

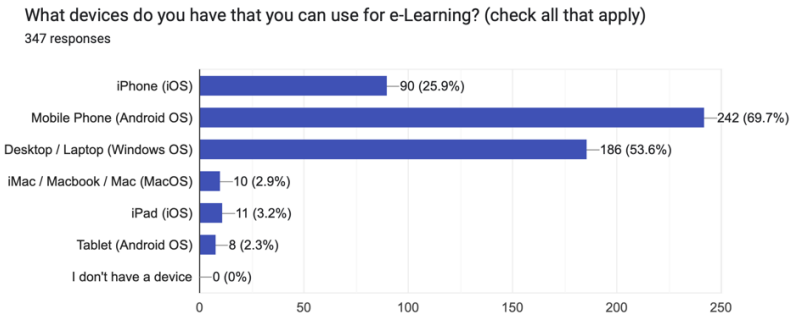

Figure 1. Most Common Devices Used for e-Learning

Figure 1 shows that according to respondents the most common device that they use is a Mobile device (Android OS). This comprises 242 respondents or 69.7%. Secondary to this is a Desktop / Laptop (Windows OS) with 186 respondents or 53.6%. The other devices are iPhone (iOS) with 90 respondents or 25.9%, iPad (iOS) with 11 respondents or 3.2%, iMac / Macbook / Mac (Mac OS) with 10 or 2.9%, and lastly a Tablet (Android OS) with 8 or 2.3%. This shows that there are available devices that learners can use for e-Learning.

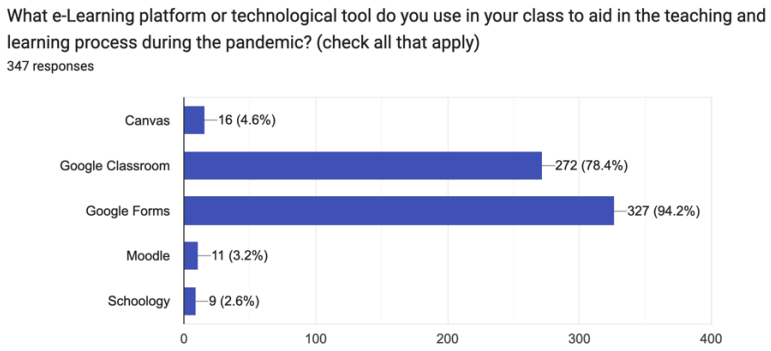

Figure 2. Most Common e-Learning Platforms Used

Figure 2 shows that according to respondents the most common tool/platform that they use is Google Forms. This comprises 327 respondents or 94.2%. Secondary to this is Google Classroom with 272 respondents or 78.4%. The other platforms are Canvas with 16 respondents or 4.6%, Moodle with 11 respondents or 3.2%, and last is Schoology with 9 respondents or 2.6%.

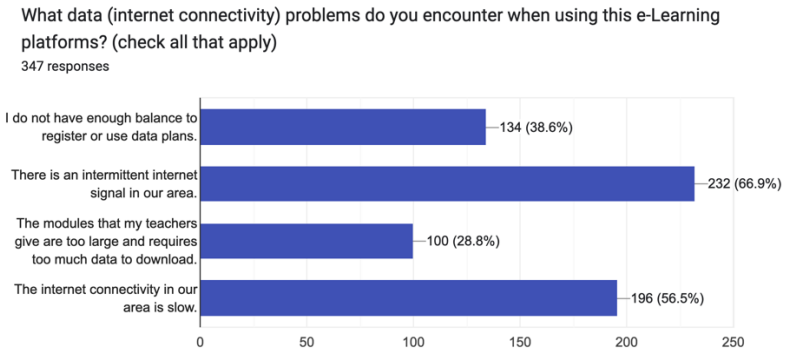

Figure 3. Most Common Internet Connectivity Problems

Figure 3 shows that according to respondents the most common internet problem that they experience when using e-Learning platforms is an intermittent signal in their respective area. This comprises 232 respondents or 66.9%. Secondary to this problem is the slow internet connectivity which 196 respondents or 56.5% claim. In the Philippines, ISP providers offer free data if only texts can be viewed. The problem is that most learning materials used in the public education sector are in pdf and picture formats. To solve this main problem, virtual DOM and Base64 was utilized in creating the new platform.

Table 3. Data Charges Incurred Using the Developed Platform

Statements	5	4	3	2	1	Mean	SD	Verbal Interpretation
B.1	1	1	1	68	276	1.22	0.47	no data charge at all
B.2	2	0	39	144	162	1.66	0.71	slight data charges

Based on the data gathered and analyzed as shown on Table 3, respondents claimed that they have accumulated no data charges at all when using the developed platform to download modules / lessons given by their teachers. It has a mean of 1.22 and a standard deviation of 0.47. Respondents also claimed that they have accumulated slight data charges when using common developed platform to accomplish tasks given by their teachers. It has a mean of 1.66 and a standard deviation of 0.71.

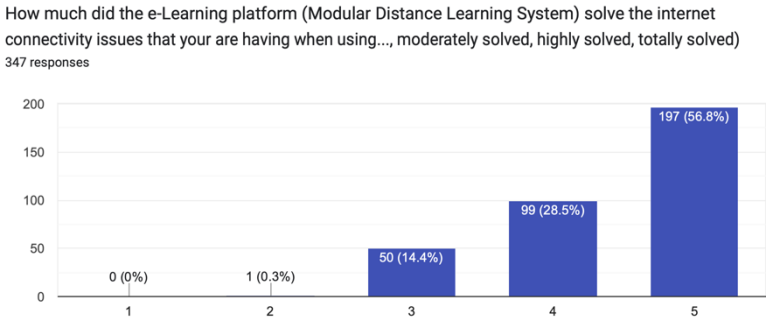

Figure 4. Internet Connectivity Issue

Figure 4 shows that according to respondents the most common internet problems were resolved by the development of a new e-Learning platform thru the utilization of Base64 and Virtual DOM compared to what they have experienced when using e-Learning platforms. A total of 197 respondents or 56.8% claim that the internet issues were totally solved while 99 respondents or 28.5% agrees that it was highly solved. A total of 50 respondents or 14.4% claim that the internet issue was moderately solved. In conclusion, the implementation of a new e-Learning platform considering the data charges imposed by internet service providers in the Philippines was a success.

5. Conclusion

The objective of this research is to address the problems that users in the public education sector experience when using the common available e-Learning platforms, particularly internet connectivity and data charges. From the result of the analysis in the data obtained from 347 respondents of the study, the following conclusions were drawn:

(1) Using the common e-Learning platforms, the students use high volume of data when downloading the modules / lessons given by their teachers; hence most students prefer to go to school and personally pick up the printed materials despite risks brought about by the pandemic.
(2) Using the common e-Learning platforms, the students use high volume of data when accomplishing the tasks / assignments given by their teachers; hence most students prefer to go to school and personally deliver their printed outputs despite risks brought about by the pandemic.

(3) Using the developed platform which utilizes Virtual DOM and Base64, the students do not use data at all when downloading the modules / lessons given by their teachers; hence, it solves the internet connection problem experienced by stakeholders. Base64 converts files into encrypted text format, this was used to take advantage of the free data charges given by ISPs in the Philippines.
(4) Using the developed platform which utilizes Virtual DOM and Base64, the students use slight data charges when accomplishing the tasks / assignments given by their teachers; hence, it solves the internet connection problem experienced by stakeholders.

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