

# Optimization of Battery Life Operation for Laptops and Personal Devices

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## Abstract:

The Coronavirus Disease 2019 (COVID-19) pandemic affected most schools and shifted into online classes, the students used their laptop devices as the main connection to cope with their school lectures and activities. Unfortunately, the students used their laptops for 8 to 10 hours depending on the school hours aside from their leisure time of using it. With this, the main objective of this study was to determine the optimization processes and solutions to prolong the battery life operation of the laptop devices used by the students for their online classes since most of the studies conducted were focused only on the battery life operation monitoring of laptops. It also determined the most used brands, their battery types and charging time on a single charge of the said devices. This descriptive study involved two hundred fifty-four (254) randomly selected students from degree programs of the College of Engineering, Architecture and Aviation during the second semester of the Academic Year 2020-2021, at the University of Perpetual Help System Laguna in the City of Biñan, Laguna, Philippines. A close-ended questionnaire with a 4-point Likert scale was used as a research instrument to gather data. Results revealed that both the current condition (normal or default setting) and applied optimization provided a significant change in terms of battery life operation and charging time. In general, this study could help the students to use the best battery optimization process for their laptop devices, and to choose the best brands when buying and using laptops in terms of battery characteristic properties aside from its requirements and specifications for their online classes.

**Keywords** —Lithium-Ion, fast charge, trickle charge, battery capacity, comparative analysis, charging time, online classes.

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## I. INTRODUCTION

With an increased number of cases in various countries and the Philippines confirmed human transmission of Coronavirus Disease 2019 (COVID-19), the World Health Organization (WHO) declared a Public Health Emergency of International Concern (PHEIC) last January 2020. <sup>[1]</sup> Nowadays, parents want to secure that their

children are in a safe place, especially those who are in kindergarten up to tertiary levels. As we are now experiencing a global pandemic, many are working and learning from home these days in the four corners of their house. Schools and universities implemented a blended learning approach to holding classes, particularly favoring online and modular approaches to instructional delivery. Even big and small companies advised their employees to

stay at home to prevent the widespread of the virus.

In connection thereto, the Department of Education (DepEd) and the Commission on Higher Education (CHED) implemented the blended and distance learning modality for the school year 2020-2021, to avoid face-to-face interactions. These education agencies and departments encourage blended and distance learning modalities which are defined as a “new method of transmitting learning”. It has three learning modalities such as modular distance learning uses self-learning modules that are printed or in digital format; online distance learning uses the Internet in downloading learning materials and uploading homework, and radio and television-based instructions to those who have no Internet connectivity.<sup>[2]</sup> Similarly, CHED also urged all higher educational institutions, public and private, to explore other flexible learning modalities that will facilitate migration from traditional to flexible teaching and learning options.<sup>[3]</sup> Similarly, school time is still the same as before the pandemic in this new normal, which takes 8 to 10 hours. As mentioned above that online distance learning is part of the said modalities, most people now are using smartphones, tablets, personal computers (PC) and most especially laptops with the latest Operating System (OS) and applications that can help the students to continue their studies and school activities through online.

Fortunately, modern laptops are much more efficient, but the most common ones can only endure up to 8 hours of battery life capacity on a single charge. Likewise, ultraportable or those with high-capacity batteries such as Dell and Apple’s MacBook laptops can only last up to 14 hours on a single charge.<sup>[4]</sup> All laptop batteries are built to handle a certain number of charge cycles, usually somewhere around 500 full cycles—and sometimes even more. Essentially, a charge cycle equals one full discharge down to 0% and then a recharge back up to 100%. A discharge down to 50% and then back to 100% would equal half a cycle. Over time, each charge cycle decreases the capacity of the battery from its design specifications, meaning that the fewer times it was drained, the longer the battery lasts.<sup>[5]</sup> With this, there are common factors to consider when optimizing the battery operations

for laptops such as display brightness, desktop background, keyboard backlights, and most especially with the Bluetooth, wireless-fidelity (Wi-Fi) and Internet sync settings.<sup>[6]</sup> Different computer applications can also be considered as one of the major factors for shortening the battery life operation, especially the engineering students who use apps with high specifications for their school activities.

Furthermore, to provide a direct power source, laptops are powered by several different types of batteries. According to one battery brand, the Lithium-ion battery performs better than the other types of batteries, and most especially it is a lightweight one. Unlike Nickel-Cadmium (NiCad) or Nickel Metal Hydride (NiMH) batteries, lithium-ion batteries do not have the dreaded “memory effect”.<sup>[7]</sup> The memory effect is the property of NiCad batteries that causes them to lose their capacity for full recharging if they are discharged repeatedly the same amount and then recharged without overcharging before they have fully drained. There is a rapid-charging option with lithium-ion batteries, which is good and more environmentally friendly than the other types. However, the NiCad battery still offers some advantages over nickel-metal hydrides, such as their extreme temperature performance. According to the Battery Depot website, NiMH battery has a high capacity compared to other rechargeable batteries. It can resist both over-charging and over-discharging, has an extremely lightweight construction, and has no hazardous chemicals like cadmium, mercury, or lead.<sup>[8]</sup>

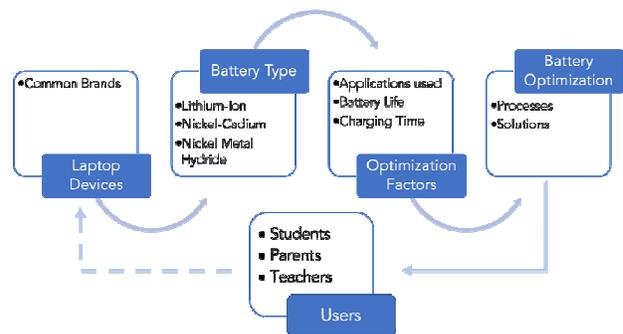


Fig. 1. The conceptual model of the study

Figure 1 showed the conceptual framework of the study in which the common laptop devices used by the students and teachers (users) for their online classes underwent an optimization process to prevent and eliminate the shortening of the battery life operation. The said process involves battery type identification, and optimization factors such as the applications used by the users, the battery life capacity and charging time on a single charge. These will result in possible solutions, which can apply by the users to prolong the battery life operation of their laptop devices.

Specifically, this study sought answers to answer the following: a.) the common laptop brands used by the students in their online classes; b.) the factors to be considered when optimizing the battery life operation for laptop devices; c.) the possible solutions to be applied when optimizing the battery life operation for laptop devices; d.) the battery life operation and charging time of the common laptop brands used by the students in their online classes in terms of its current condition (default setting) and applied optimization and e.) the significant difference between the current condition and applied optimization solutions used for laptop devices in terms of average battery life operation and charging time per brand. This study could provide empirical insights for parents, guardians, teachers, and most especially for the students to prevent and eliminate the cases of shortening the battery life operation of their laptop devices. It could also help them to choose the best brands to consider when buying laptops aside from their requirements and specifications for their online classes.

## **II. METHODOLOGY**

The descriptive method was used for research design to illustrate existing conditions so that these could be manipulated later as an outcome of the study. Quantitative research was used since it inspects the connection among variables by testing independent laptop devices and their characteristic properties.

The total student population of the College of Engineering, Architecture and Aviation of the University of Perpetual Help System Laguna was

740 students from different degree programs during the Academic Year 2020-2021. It was composed of 62 Architecture (Arch.) students, 214 Civil Engineering (CE) students, 51 Computer Engineering (CpE) students, 81 Electrical Engineering (EE) students, 41 Electronics Engineering (ECE) students, 155 Industrial Engineering (IE) students, and 136 Mechanical Engineering (ME) students. Specifically, cluster sampling was used in selecting the respondents by degree program. The number of samples was computed using Stovin's formula with a 5% marginal error. Two hundred fifty-four (254) students were randomly selected, composed of 21 Architecture (Arch.) students, 73 CE students, 18 CpE students, 28 EE students, 14 ECE students, 53 IE students and 47 ME students.

A closed-ended questionnaire with a 4-point Likert scale was used as the research instrument. It consisted of the laptop brand used by the students, charging time, battery type and its life operation, and other supplementary questions, which can be support for data analysis. The Likert scale used has 4-point numerical values from 3.25-4.0 with a categorical response of strongly disagree and interpretation of very high and very effective; 2.50-3.24 for agreeable response with high and effective interpretations; 1.75-2.49 for disagree with low and ineffective interpretations; and 1.00-1.74 for strongly disagree with very low and very ineffective interpretations as shown in Table II of this study.

For statistical treatments, weighted mean, composite mean or average was used for rating the battery's current condition and applied optimization. Relatedly, the z-test was used to determine the significant difference between the said battery conditions. Validation was executed by the research experts of the university, which included the authenticating, maintaining, and studying of every data collected.

## **III. RESULTS AND DISCUSSIONS**

This study mainly aimed to determine the factors to be considered when optimizing the battery life operation for laptop devices and the possible solutions to be applied when optimizing the battery life operation for laptop devices through the

weighted means of the data gathered from the survey. It also included the battery life operation and charging time of the common laptop brands used by the students. Furthermore, this section also includes the most common laptop devices used by engineering and architecture students, which ranked from greatest to least. The significant difference between the normal setting and applied optimization processes and solutions in terms of battery life operation and charging time was also presented together with their analyses and interpretations.

**A. The most common laptop devices used by engineering students and their ranking**

TABLE I  
 THE MOST COMMON LAPTOP DEVICES USED BY ENGINEERING STUDENTS AND THEIR RANKING

Brand	Students by Degree Programs							Total (Brand)	Rank
	Arch	CE	CpE	EE	ECE	IE	ME		
Acer	5	16	6	10	0	8	13	58	2
Apple	1	1	0	0	0	1	0	3	7
Dell	3	8	0	0	2	5	3	21	5
Asus	4	12	4	2	7	8	13	50	3.5
HP	4	18	5	4	3	13	3	50	3.5
Lenovo	4	17	3	12	2	15	15	68	1
Others	0	1	0	0	0	3	0	4	6
Total (Students)	21	73	18	28	14	53	47	254	

Table I shows that the common laptop brand used by the students was Lenovo with almost 27% (68 students) of the total respondents followed by Acer with 23% (58 students). Meanwhile, HP (Hewlett-Packard) and Asus’s laptop devices both had 20% (50-50 students), respectively. Twenty-one (21) students or less than 9% of the respondents used Dell laptop computers, while the other brands such as Microsoft and Apple’s MacBook laptop devices were both used by 7 students only or less than 3% of the respondents.

Based on the gathered results, there are common factors which were considered by the students when buying or using laptop devices for their online classes such as the requirements and specifications, portability, durability and most especially the price (affordability). Also, the gathered results proved that price had the major factor because most of the laptops used by engineering students varied from PHP 20,000 (USD 350.00) to PHP 28,000 (USD 650.00).<sup>[9]</sup> Moreover, Apple’s MacBook Pro,

Dell’s ThinkPad, HP’s EliteBook and other expensive brands were used by most companies and described also as the best business laptop devices this 2021, especially for those who are now working from home.

**B. The factors affecting the current condition (default setting) of the laptop devices used by the engineering students**

TABLE III  
 THE LIKERT SCALE WAS USED FOR THE FACTORS AFFECTING THE CURRENT CONDITION (DEFAULT SETTING) AND APPLIED OPTIMIZATION PROCESSES AND SOLUTIONS FOR LAPTOP BATTERIES

Numerical Value	Mean Value	Categorical Response	Interpretation	
4	3.25 – 4.00	Strongly Agree	Very High	Very Effective
3	2.50 – 3.24	Agree	High	Effective
2	1.75 – 2.49	Disagree	Low	Ineffective
1	1.00 – 1.74	Strongly Disagree	Very Low	Very Ineffective

Table II shows the Likert scale rating equivalent used for the evaluation and scoring. This was to determine the factors affecting the current condition (default setting) and applied optimization processes and solutions for better battery life operation and charging time through weighted means, which came from the data gathered from the survey assessed by the respondents.

Table III below shows the factors affecting the current condition (default setting) of the battery life operation of the laptop devices used by the students. The students responded to the survey by stating how high or low the factors affected the battery life operation. Based on these results, enabled e-mail and Internet sync settings, enabled Bluetooth and Wi-Fi (wireless-fidelity) connections, and full display brightness was the very highly affected factors, which garnered an average weighted means of 3.73, 3.70 and 3.51, respectively. Secondly, the students also stated that the high affecting factors with an average weighted mean of 3.46 were the normal setting, disabled battery save mode, and multiple running applications used (other factors). Using of multiple applications was also considered as affecting factor since 78% of the students are using 3 to 4 applications, while 34 of them (12%) were using 5 to 6 applications, and the remaining

10% are using 7 and more applications during their online classes based on the supplementary survey conducted.

watt-hours (Wh) of a battery). More cells or higher watt-hours in the battery can power the laptop for a long time under the same operating conditions.

TABLE IIIII  
THE FACTORS AFFECTING THE CURRENT CONDITION (DEFAULT SETTING) OF THE LAPTOP DEVICES USED BY THE ENGINEERING STUDENTS

Factors	Weighted Mean by Brand						Average (Factors)
	Lenovo	HP	Acer	Asus	Apple	Dell	
Full display brightness	3.18	3.16	3.70	4.00	3.42	3.61	3.51
Bright and colorful desktop background	3.20	2.85	2.93	3.60	2.39	2.54	2.92
Full keyboard backlight	3.15	2.79	2.84	3.80	2.48	3.72	3.13
Enabled Bluetooth and Wi-Fi connection	3.42	3.52	3.60	4.00	3.86	3.80	3.70
Enabled e-mail and Internet sync settings	3.32	3.74	3.80	4.00	3.84	3.68	3.73
Others	2.60	3.34	3.63	4.00	3.36	3.85	3.46
Average (Brands)	3.15	3.23	3.42	3.90	3.23	3.53	

TABLE IVV  
THE POSSIBLE SOLUTIONS FOR OPTIMIZATION OF THE LAPTOP DEVICES USED BY THE STUDENTS IN TERMS OF BATTERY LIFE OPERATION AND CHARGING TIME

Optimization Processes and Solutions	Weighted Mean by Brand						Average (Optimization)
	Lenovo	HP	Acer	Asus	Apple	Dell	
Decrease display brightness	3.82	3.80	2.84	3.81	3.37	3.71	3.56
Use a plain (not bright) desktop background	2.80	3.20	2.93	2.80	3.60	3.20	3.09
Decrease keyboard backlight	3.76	3.67	3.70	3.77	3.61	3.65	3.69
Disabled Bluetooth and Wi-Fi connection	3.68	3.66	3.80	3.58	3.73	3.75	3.70
Disabled e-mail and Internet sync settings	3.80	3.60	3.60	4.00	3.60	3.60	3.70
Others	3.85	3.67	3.63	3.99	3.66	3.62	3.74
Average (Brands)	3.65	3.61	3.45	3.82	3.49	3.59	

Moreover, using of full keyboard backlight gained an average weighted mean of 3.13, which is also considered a high affecting factor. Lastly, the low affecting factor was using a bright and colorful background, which gained an average weighted mean of 2.92. On the other hand, Asus, Dell, and Acer laptop devices were highly affected by the common factors to their battery life operations, which gained an average weighted mean of 3.90, 3.53, and 3.49, respectively. The students also agreed that Apple, HP, and other laptop brands were also highly affected garnered an average weighted mean of 3.23, while the least affected was Lenovo brand, which also earned a high rating of 3.15.

Based on one published article, laptop configuration and power settings can also have an impact on battery performance<sup>[11]</sup>, and these include the common factors mentioned above. Likewise, the difference between battery life operation and capacity. Battery life or battery run time is how long a battery lasts between charges. Battery life depends on battery capacity (number of cells or

Additionally, battery capacity is a measure of charge that can be stored in the battery. The capacity of a battery reduces as the battery chemically ages which results in lesser hours of usage between charges. The maximum battery capacity measures the capacity of the battery relative to when it was new. With this said affecting factors and gathered results, these proved that all the laptops were highly affected in terms of their battery life operations and capacity.

*C. The possible solutions for optimization of the laptop devices used by the students in terms of battery life operation and charging time*

Table IV above shows the common optimization processes and solutions, which can help the prolonging of the laptop battery life operation used by the students. Managing the battery usage for different running applications, turning off, hibernate mode, and sleep mode (other factors) laptops while charging are the very effective solutions used by the students for battery optimization, which garnered an average weighted mean of 3.74, but these other factors cannot be applied during online classes.

Secondly, the students strongly agreed also that disabling Wi-Fi and/or Bluetooth connections, and e-mail and Internet sync settings were also very effective during online classes, which gained an average weighted mean of 3.70. This was followed by decreasing the keyboard backlight and display brightness, which earned also a very high rating average of 3.69 and 3.56, respectively based on the gathered results. Finally, using a plain and not bright or colorful desktop background was also an effective solution according to the students, which gained a high rating average of 3.09, even though Apple laptop users responded that it had a very high impact on its battery life operation. Moreover, the gathered results were also analyzed and interpreted based on the different laptop brands used by the students. The common optimization processes and solutions mentioned above were very effective for Asus, which came first on the survey and earned an average weighted mean of 3.82. In addition, Lenovo, HP, and Dell laptops also gained a very high response to the said solutions, which garnered average ratings of 3.65, 3.61, and 3.59, respectively. Lastly, Apple, Acer and other laptop brand users agreed that their batteries were effectively optimized with average ratings of 3.49 and 3.45, respectively.

Since modern laptops today do not have removable batteries and swapping one battery out for a fully charged spare is not an option. Likewise, many of the latest ultraportable laptops have enough battery power to last all day (for approximately 16 hours)<sup>[4],[12]</sup> but as for the students, they only used common battery-installed laptops with an average battery life operation of 6 to 10 hours only as shown in Table V of this study. Almost 94% (or 238 students) of the total respondents were aware of the battery life optimization solutions mentioned above and using them based on the supplementary survey conducted. These combined and analyzed results proved that the common laptop battery optimization processes and solutions were very effective and generally used by the students. This is to maintain the battery life operation and charging time especially since all the students (100%) responded that they are using only one (1) laptop during their online classes.

**D. The battery life operation and charging time of the common laptop brands used by the students in terms of their current condition (default setting) and applied optimization**

TABLE V  
THE POSSIBLE SOLUTIONS FOR OPTIMIZATION OF THE LAPTOP DEVICES USED BY THE STUDENTS IN TERMS OF BATTERY LIFE OP

Brand	Battery Type	Current Condition (Default Setting)		Applied Optimization	
		Battery Life Operation	Charging Time	Battery Life Operation	Charging Time
Acer	Lithium Polymer	7	2	9.5	1.75
Apple	Lithium Ion	12	2.5	14.5	2.25
Asus	Lithium Ion	8.5	1.5	10	1.25
Dell	Lithium Ion	16	2.5	17	2.00
HP	Lithium Ion	9.5	1	11.5	0.75
Lenovo	Lithium Ion	6	2	9.5	1.75
Others	Lithium Ion	11	2.5	12.5	2.00

Table V shows the different types of batteries, battery life operation and charging time of the laptop devices used by the respondents. Similarly, it shows that most of the battery types were Lithium-ion and Lithium-polymer, while the average battery life operation was approximately 10 hours for seven different brands. The battery life operation was gathered in hours, which ranged from 6 to 16 hours. Furthermore, the current condition of the charging time of the said laptops ranged from 1 to 2.5 hours depending on their brand. On the other hand, it also shows the average optimized battery life operation (12.07 hours) from seven different brands had an increase of approximately 2 hours. In contrast with the 6 to 16 hour-range for the current condition, the optimized battery life operations now ranged from 9.5 to 17 hours. Additionally, the optimized battery charging time of the said laptops ranged from 45 minutes to 2 hours and 15 minutes with a slight decrease depending on its brand.

TABLE VI  
 THE DIFFERENCE BETWEEN THE CURRENT CONDITION (DEFAULT SETTING) AND APPLIED OPTIMIZATION SOLUTIONS USED FOR LAPTOP DEVICES IN TERMS OF AVERAGE BATTERY LIFE OPERATION PER LAPTOP BRAND USED BY THE STUDENTS

Brands	Average Battery Life Operation		z-Value	p-Value	Interpretation
	Current Condition (Default Setting)	Applied Optimization			
Acer	7	9.5	-30.805	<0.00001	Significant
Apple	12	14.5	-8.319	<0.00001	Significant
Asus	8.5	10	-12.907	<0.00001	Significant
Dell	16	17	-8.142	<0.00001	Significant
HP	9.5	11.5	-18.595	<0.00001	Significant
Lenovo	6	9.5	-29.272	<0.00001	Significant
Others	11	12.5	-6.252	<0.00001	Significant

\* Critical value at 5% level of significance = +/-1.96

TABLE VII  
 THE DIFFERENCE BETWEEN THE CURRENT CONDITION (DEFAULT SETTING) AND APPLIED OPTIMIZATION SOLUTIONS USED FOR LAPTOP DEVICES IN TERMS OF AVERAGE BATTERY CHARGING TIME PER LAPTOP BRAND USED BY THE STUDENTS

Brands	Average Battery Charging Time		z-Value	p-Value	Interpretation
	Current Condition (Default Setting)	Applied Optimization			
Acer	2.00	1.75	4.417	0.000010	Significant
Apple	2.50	2.25	3.875	0.000107	Significant
Asus	1.50	1.25	3.62	0.000295	Significant
Dell	2.50	2.00	5.946	<0.00001	Significant
HP	1.00	0.75	3.192	0.001413	Significant
Lenovo	2.00	1.75	3.753	0.000175	Significant
Others	2.50	2.00	4.143	0.000034	Significant

\*Critical value at 5% level of significance = +/-1.96

The most expensive laptops are mostly for business purposes such as Apple, Dell, Microsoft and MSI, and they can be used from 11 to 16 hours until they become low in battery. <sup>[10]</sup>In addition, most of the laptops used by the students are now using Lithium-ion batteries with approximately 2 hours of charging time. These batteries are charged by two methods--fast charge and trickle charge. According to Apple, when the battery is completely run down, the charger will use a fast charge voltage and amperage to bring the battery up to about 80% full operation in about 2 hours on a single charge. After two hours, the charging voltage and amperage gradually decrease and change into a trickle charge until the battery is 100% charged with an additional charging time of approximately 30 to 45 minutes. <sup>[13]</sup>The gathered results also proved that all the laptop devices used by the students have a charging time of approximately 2 to 2.5 hours. Moreover, the optimization solutions can increase the battery life operation of laptop devices, but there was only a slight decrease in terms of

charging time. Most laptop chargers, today use both fast charges and trickle charges for about 2 hours on a single charge. Therefore, the trickle charging is dependent on the laptop operation and running application used at the time of charging. These proved that the charging time will still become longer during the trickle charging with a constant additional 30 to 45 minutes charging time if the said optimization solutions were not applied.

*E. The significant difference between the current condition and applied optimization solutions used for laptop devices in terms of average battery life operation and charging time per brand*

Table VI and Table VII above show the difference between the current condition (normal or default setting) and the applied optimization of battery life operation and charging time. The gathered data came from the results of Table V of this study. Based on the battery life operation as shown in Table VI, the current condition gained an average of 10 hours while the applied optimization earned an average of 12.07 hours. It has an increase

of 2 hours when the optimization solutions were applied. On the other hand, Table VII shows the average charging time, the current condition (default setting) obtained an average of 2 hours while the applied optimization earned an average of 1.68 hours or approximately 1 hour and 41 minutes. It has a decreased 0.32 hours (19.2 minutes) or approximately 20 minutes when optimization solutions were applied. With this, all data gathered underwent a z-test obtained p-values at a 5% significance level are less than 0.05 (p-value < 0.05), giving a rejected hypothesis ( $H_0$ ), thus the interpretation being significant.

Proving that the produced means from the samples of the battery life operation and charging time have a significant difference considering that chances were not just coincidence, and it was solved with a z-test. As such, an evaluation was conducted of the difference between the current condition (default setting) and the applied optimization for laptop batteries made a significant change as the p-value met the required condition to reject the hypothesis. These results proved that the main problem of this study provided a credible solution using the applied battery optimization processes and solutions for all laptop devices used by engineering and architecture students.

#### **IV. CONCLUSIONS AND RECOMMENDATIONS**

The online classes have an impact on the students and their parents in terms of expenses because of the laptop devices used besides the Internet connectivity because most of the laptops used by the engineering and architecture students were Lenovo, Acer, Dell, and HP brands, which varied from PHP 20,000 (USD 350.00) to PHP 28,000 (USD 650.00) only. Furthermore, the average battery life operation of laptops was 10 hours from 6 to 16 hours, while the average charging time of 1.68 hours (1 hour and 41 minutes) from 1 to 2.5 hours depending on its brand.

As mentioned, the average battery life operation was most affected by the normal or default settings such as enabled e-mail and Internet sync settings, enabled Bluetooth and Wi-Fi connections, and full

display brightness of the laptops. This study applied the most common battery optimization processes and solutions such as managing the battery usage for different running applications, turning off, hibernate mode, sleep mode, disabling Wi-Fi and/or Bluetooth connections, and e-mail and Internet sync settings since most of the laptop batteries today were made of Lithium-ion or Lithium-polymer. Lithium-ion batteries for laptops today are built-in and cannot be replaced easily for another fully charged one.

Based on the gathered results, the applied common processes and solutions for optimization are very effective and could prolong the lifespan. These mentioned solutions also have significantly increased the battery life operation from 1 to 2 hours compared to the normal and current conditions depending on its brand and battery type. In connection, Lithium-ion batteries are now the most used for laptops, which are more lightweight and can resist fast and trickle charging, compared to the other battery types. Likewise, the optimization solutions also significantly affect the charging time because Lithium-ion battery chargers are now using fast charging when the battery is low until it reaches 80% for about 2 hours then gradually change into trickle charging to be full on a single charge. Trickle charging is dependent on the laptop operation and running application used at the time of charging. The charging time will still be the same during the trickle charging even if the said optimization solutions were applied. Conclusively, batteries of any laptop brand, like all rechargeable batteries, are consumable components that become less effective as they age. Therefore, as the battery ages, the peak capacity and battery lifespan also reduce.

This study recommends to laptop users, especially students use a laptop with Lithium-ion high-capacity batteries such as Dell to have a long-life operation during online classes. This is also recommended to apply the common optimization processes and solutions to prolong and maintain its life operation. Most of the common operating systems installed in laptops are Windows and macOS, which have battery settings that can be applied together with the common ones. This study

also recommends to users always check the battery health management for battery health status. Monitoring the temperature of laptops and charging patterns can also be an effective solution to maintain the battery lifespan, especially for students during online classes. Charging patterns also include the staying of laptop charging on the plug while using it which is not a good practice. Battery charges to a level optimized for the end user's usage should also be ensured.

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## REFERENCES

- [1] Department of Health (DOH), *Interim Guidelines on the Preparedness and Response to Novel Corona Virus (2019-nCoV) from Wuhan, China (as of January 21, 2020)*, 2020 [Online]. Available [https://doh.gov.ph/sites/default/files/health-update/DM-2020-0034-Interim-Guidelines-on-the-Preparedness-and-Response-to-2019-nCoV\\_0.pdf](https://doh.gov.ph/sites/default/files/health-update/DM-2020-0034-Interim-Guidelines-on-the-Preparedness-and-Response-to-2019-nCoV_0.pdf).
- [2] M. Quinones, *DepEd clarifies blended, distance learning modalities for SY 2020-2021*. Philippine Information Agency (PIA), 2020 [Online]. Available: <https://pia.gov.ph/news/articles/1046619>.
- [3] Commission on Higher Education (CHED), *Guidelines on the Implementation of Flexible Learning*, 2020 [Online]. Available: <https://ched.gov.ph/wp-content/uploads/CMO-No.-4-s.-2020-Guidelines-on-the-Implementation-of-Flexible-Learning.pdf>.
- [4] T. Brant, *The Best Desktop Computers for 2021*. PCMag, 2021 [Online]. Available: <https://www.pcmag.com/picks/the-best-desktop-computers>.
- [5] T. Lacombe, *How to care for your laptop's battery and extends its life?*, 2021 [Online]. Available: <https://www.digitaltrends.com/computing/how-to-care-for-your-laptops-battery/>.
- [6] M. Hanson, *Top tips for extending the battery life of your laptop*, 2018 [Online]. Available: <https://www.techradar.com/news/mobile-computing/10-ways-to-make-your-laptop-battery-last-longer-513756>.
- [7] Willey Brand, *The Different Types of Laptop Batteries*. Dummies: A Willey Brand, 2021 [Online]. Available: <https://www.dummies.com/computers/pcs/battery-life/the-different-types-of-laptop-batteries/>.
- [8] Battery Depot, *What is the Difference Between NiCad and NiMH?*, 2021 [Online]. Available: <https://www.batterydepot.com/blog/difference-between-nicad-and-nimh/>.
- [9] Vines Price Price, *Best Laptops Under P20K for e-Learning/Online Class in the Philippines 2021*, 2021 [Online]. Available: <https://ph.priceprice.com/laptops/news/e-learning-online-laptops-9310/>.
- [10] P. Tracy, *Best Business Laptops in 2021*. Laptop Mag, 2021, June 20 [Online]. Available: <https://www.laptopmag.com/articles/best-business-laptops>.
- [11] Dell Technologies, *How to Improve the Performance of a Dell Laptop Battery*, 2021, February 21, no. 000123091 [Online]. Available: <https://www.dell.com/support/kbdoc/en-ca/000123091/how-to-improve-the-performance-of-a-dell-laptop-battery>.
- [12] J. Martin, *How to improve battery life*. Tech Advisor, 2019, September 2 [Online]. Available: <https://www.techadvisor.com/feature/laptop/how-improve-laptop-battery-life-3462609>.
- [13] Apple, *How battery health management helps*, 2021 [Online]. Available: [https://support.apple.com/en-ca/HT211094?cid=mc-ols-energy\\_saver-article\\_ht211094-macos\\_ui-04022020](https://support.apple.com/en-ca/HT211094?cid=mc-ols-energy_saver-article_ht211094-macos_ui-04022020).