Spatial and Temporal Pattern of Internet Engagement of Campus Community in Relation to Internet Reliability at ITB Jatinangor Campus

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ABSTRACT
Since the beginning of its operation in 2011, the number of study programs in ITB Jatinangor, as well as the number of its students, lecturers, and administrative personnel being employed, have increased significantly. To digitally serve the community, the management of ITB Jatinangor campus, in coordination with the Directorate of Information Systems and Technology of ITB, has significantly increased the number of internet access points within the campus, from only 10 access points in 2011 to 144 access points in 2019. In this study, we analyzed traffic of internet network usage, especially Wi-Fi network, spatially and temporally, by measuring bandwidth at 25 buildings which cover 65 access points as samples, during day and night times. The data were then compared to traffic history in the management system. An online survey on student behavior related to internet usage was also conducted. In general, we found that internet reliability at Jatinangor campus can be categorized as fairly good, as the respondents gave a score of 3 on a scale of 5. Disruption of internet connectivity at Jatinangor campus often occurs due to unavoidable external factors. Respondents generally (60%) accessed the internet for more than 5 hours every day, especially between 5.00 pm to 9.00 pm. Students accessed Wi-Fi from several places such as student dormitories, lecture rooms, student association rooms, libraries, and canteen. They used the internet mostly (40%) to browse and download material related to lectures, while the rest was mostly for social media, watching movies, or keeping abreast of the news. Besides the number of access points, internet access speed depends on the number of users connected to the internet, the allocation of available bandwidth, and the level of bandwidth consumption. As the covid-19 is not over yet, most of the courses will be conducted virtually. This condition has emphasized the necessity to increase internet reliability on campus and prepare the campus as a smart and green campus for a much safer and healthy environment in pursuing excellence in the academic atmosphere.

Keywords: *Campus, Internet Reliability, ITB, Jatinangor.*

1. INTRODUCTION

ITB Jatinangor Campus has been operating since 2011. The student population at ITB Jatinangor Campus as of July 15, 2019 is 2307 people, distributed in seven faculties or schools that cover 16 study programs. From that number, 432 students are ITB Cirebon students from four study programs. The addition of the total number of students each year ranges from 100-300 students.

Over time, along with the increasing number of students, the number of internet access points must be increased because higher education cannot be separated from the world of the internet, both fixed on the spot and mobile. In general, students need access to browse, upload and download on the internet in carrying out their learning activities. Today, the internet and smartphones have become the primary consumption of students' activity on campus.

Moreover, the Covid 19 pandemic outbreak has imposed all campuses in almost all countries to stop or minimize their traditional way of face-to-face teaching and learning activities, including administrative activities, and turned to much more virtual business activities. Therefore, internet connection reliability on the campus and at homes, since lecturers, students, and

administrative staff mostly work from home (WFH), becomes more important.

A campus network is far more than just physical infrastructure. Planning and building a campus network means developing a new information environment that will have a meaningful impact on every aspect of campus life. [1]

Digital learning processes and experiences enhance traditional textbooks and upending conventional classroom teaching methods, where online lessons, testing, and assessments are now part of most curricula. In this process, laptops and gadgets have become primary instruction tools for students to download an increasing number of online apps in their gadgets. Lecturers rely on robust and reliable Wi-Fi across their campus to access the full range of relevant teaching tools [2].

The challenges ahead will be even stronger due to the Covid-19 outbreak, which end has not been predicted. This circumstance has led the teaching-learning processes to be done mostly online, which demands the internet network system's reliability on campus. Moreover, some study programs such as landscape architecture, urban planning, design, and art are more likely to need the internet to do creative design processes and space production.

A well-designed physical campus, completely integrating technology and a green environment, is essential for building a digital university by enhancing the student experience and providing the needed settings and facilities for learning and research activities to promote, support, and encourage lifelong learning [3]. This study investigated how reliable the internet network at Jatinangor ITB campus is spatially and temporally to meet the needs of teaching and learning processes for students and lecturers with an increasing population and increasingly varied study programs. Besides, it becomes an input for strategy and planning strengthening the internet network at the ITB Jatinangor campus to face IoT era and realize a green campus strategy.

2. METHODOLOGY

In collecting necessary data and information regarding internet conditions and its development from time to time in ITB Jatinangor campus, we first conducted a thorough document review followed by focus group discussion with staff involved in the directorate's information section ITB Jatinangor campus. Secondly, we measured internet speed and signal strength in 60 access points (out of 144) distributed in various locations and buildings at the campus in the morning (7.00 to 8.00 am) and in the evening (7.00 pm) using a phone cell and Speedtest application. Traffic history of internet usage during the measured period was analyzed from system management and control of point access in the server of ITB Jatinangor Campus.

An online survey was conducted to students in ITB Jatinangor campus, which features ten questions (Table 1.) on SurveyMonkey.Com. The survey was conducted before the outbreak of Covid-19.

Table 1 Online survey to users using surveymonkey.com.

No	Questions	Alternative Answers
1	How long in a day do you engage in the internet through the campus WiFi network?	a. More than 5 hours b. 3-5 hours c. 1-3 hours d. Less than 1 hour
2	What time do you spend most on accessing the internet?	a. Before 9.00 am b. Morning/day 9.00 am – 1.00 pm c. Day/afternoon 1.00 pm – 5.00 pm d. Afternoon/night 5.00 pm – 9.00 pm
3	How often is your internet connection interrupted?	a. Quite often b. often c. rare d. very rare
4	Rate internet reliability in the dormitory (1: very poor, 2: poor, 3: moderate, 4: good, 5: Excellent	1 2 3 4 5
5	Rate internet reliability in lecture rooms	1 2 3 4 5
6	Rate internet reliability in library	1 2 3 4 5
7	Rate internet reliability in the cafeteria	1 2 3 4 5
8	Rate internet reliability in your students' association office	1 2 3 4 5
9	Rate internet reliability in open space	

10	What do you most frequently do while on the internet?	a. Browsing and downloading course materials and related subjects b. Social media activities c. Watching movies and entertainment on YouTube and others d. Reading news and information

3. RESULTS AND DISCUSSION

3.1 Spatial Pattern of buildings distribution in ITB Jatinangor Campus

The ITB Jatinangor campus is located in a 43 ha area, with a cluster of buildings mostly is located from the center and stretching to the northern part, while the southern part is more dominated by the presence of vegetation cover and a lake (Figure 1). The buildings consist of general lecture buildings, laboratories, offices, and student dormitories. The pattern of building distribution is concentrated or close together and connected by corridors. This pattern facilitates easy movement of people between buildings, shelter them from rain and direct exposure to sunlight, and facilitate easy withdrawal of cables and access points for the internet. New building construction is still underway, including for the student dormitory, which currently has around 1200 students. Some more buildings for laboratory and office for new study programs are also needed to be built; therefore, some vegetation covers will be replaced by more buildings.

The increase in building number is in line with the increased number of study programs opened. At the beginning of operation in 2011, there was only one study program, i.e., the Bioengineering study program (Rekayasa Hayati) with 40 students. The following year, the Management of Clean Water and Sanitation (FTSL) study program was established. In 2013, four new study programs were opened, including Agricultural Engineering (SITH), Forestry engineering (SITH), Entrepreneurship (SBM), and one magister's degree program, i.e., landscape architecture. In 2014, two new study programs were added: environmental infrastructure engineering (RIL) and the technology of water resources management (TPSDA). After that, the addition of new study programs occurred in 2016 consisting of 6 study programs, and in 2017 a study program of metallurgical engineering was opened, while in 2019, a study program of Geophysical Engineering was opened.

3.2 Distribution and increase of internet access points since 2011

In 2011, ten internet access points were installed at the ITB Jatinangor campus. The installation of additional access points must be planned based on users' requests and the university's budget availability. In 2012, 28 points were installed. The highest addition of access points occurred in 2016, as 48 access points were installed. In 2019, there was an increase of 27 points (Table 2 and 3). The total number of access points that have been installed by 2019 is 144 points. The highest number of access points installed are in student dormitories (57 points), followed by laboratories (37 points).

Figure 1 Map of ITB Jatinangor campus in 2019

No	Year	Total AP	Buildings/Locations	Quantity of installed AP
1	2011	10		
2	2012	38	Main building	3
			Dormitory TB1	10
			Dormitory TB2	10
			C- Building	1
			Library	4
3	2013	45	Computer Laboratory (Labkom)	6
			Labtek 2B	1
			Koica Building	Nd
5	2015	113	GKU 1	8
			A-Building	1
			TB3 Dormitory	10
			TB4 Dormitory	10
			E-Building	3
			D-Building	3
			Labtek 1-B	10
			Main Gate	1
			Forestry Building	2
6	2016	114	Bus Pool	1
7	2017	114	-	0
8	2018	117	Al-Jabbar Mosque	2
			Herbarium	1
9	2019	144	Sedimentation Lab	6
			Lecturer's dorm	15
			Waste treatment Office (IPST)	1
			Amphitheater	2
			Multipurpose Building (GSG)	3

Table 2 Accumulation of access points (AP) installed from 2011 to 2019

General rooms	Lecture	Laboratories		Offices and General Facilities		Dormitories	
GKU-1	8	Labtek -1a	10	Main Build	10	Student Dorm.	42
GKU-2	8	Labtek -1b	10	Library	4	Lecturers Dorm.	15
Build.	1	Sedimentation lab.	6	Multipurpose Bld (GSG)	3		
B-Build	2	Herbarium	2	Waste treatment	1		
C-Build	1	Labkom	6	Al-Jabbar Mosque	2		
D-Build	3	Lab Fisika-kimia	1	Bus Pool	1		
E-Build	3	Forestry Bld	2	Main Gate	1		
				Amphitheater	2		
Total	26		37		24		57

Table 3 Internet access points distribution at ITB Jatinangor Campus as of 2019.

3.3. Internet Speed

From internet speed measurement at 60 access points, out of the total available 144 points, the best sites for downloading and uploading files vary between day and night. The main building (1st floor) was found as the worst both for downloading and uploading internet activities in the morning, but at night, the library (2nd floor) and Labtek 1B were the worst sites for downloading and uploading, respectively (Table 4).

From the traffic record of internet users, student dormitory TB3 on the 4th floor was the best site in the morning and night. The minimum required internet speed for various activities according to FCC [4] is specified in the following table (Table 5).

Actions	Morning (Mbps)		Night (Mbps)	
Download – best	TB3 Dorm third fl.	54.14	TB3 Dorm 3rd fl.	54.72
Download – worst	Main Bld first fl.	0.00	Library 2nd fl.	0.00
Upload –best	Lecturers Dorm second fl.	58.96	Labtek V-a 2nd fl.	41.64
Upload – worst	Main Bld first fl.	0.00	Labtek 1-B. 5th fl.	0.00

Table 4 Best and worst sites for download and upload

	Activities	Minimum speed (Mbps)
1	Web Browsing	0.5 -1.0
2	Streaming Music	0.5
3	Phone Calls (VoIP)	0.5
4	Streaming Videos	0.7
5	Streaming Movies (Non-HD)	1.5
6	Streaming HD Quality Movies	4
7	Basic Video Conferencing	1
8	HD Video Conferencing	4
9	Internet-Connected Game Console	1
10	Online Multiplayer HD Gaming	4

Table 5 Table of FCC minimum required download speed [4]

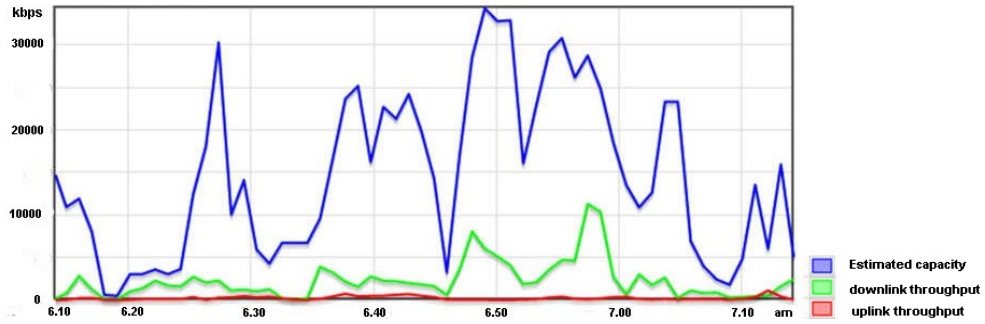

Figure 2 Bandwidth use at student dormitory TB3 (4th floor) measured in the morning

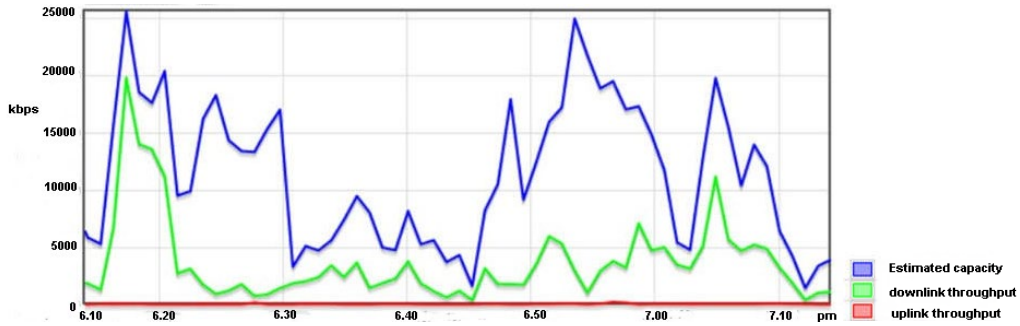

Figure 3 Bandwidth use at student dormitory TB3 (4th floor) measured at night

Meanwhile, bandwidth is measured as the amount of data that can be transferred from one point to another within a network in a period of time, expressed as a bitrate, and measured in bits per second (bps). Bandwidth means the transmission capacity of a connection; it is an important factor to determine the quality and speed of an internet connection network [4,5]. ITB Jatinangor campus has allocated 1 Gigabit bandwidth. The traffic of bandwidth used at TB3 (4th floor) in the morning (Fig. 2) and night (Fig. 3) showed the pattern of the busy time was around 7.00 in the morning and around 7.00 in the evening.

3.4. Signal Strength

The greater the signal, the better the internet access speed is. The unit for signal strength is in dBm. The category of signal strength can be seen in Table 6 below. Referring to the signal strength, Table 7 shows that the signal strength can be categorized as fair to good.

	Morning (dBm)		Night (dBm)	
Signal -strongest	Lecturer dorm fifth fl.	-27	Main Bld first fl. Lecturer dorm fifth fl. Labtek V-a	-31
Signal Weakest	Main Bldg first fl.	-93	Koica Bldg third fl.	-91

Table 6 Signal Strength

RSSI* (dBm)	**Signal Strength**
>-70	Excellent
-70 to -85	Good
-86 to -100	Fair
<-100	Poor
-110	No Signal

RSSI: Received Signal Strength Indicator

Table 7 Signal strength measurement in dBm (Paessler, 2020)

3.5. Behavior of Users

Most of the students (55%) accessed the internet for more than five hours on a typical day (Fig. 4), while 20% accessed the internet for 3-5 hours a day. In total, students accessed the internet generally (75%) more than three hours a day. As a comparison, in a survey conducted in 2018 at Carnegie College on how long students spent their time in online activities on a typical day, the answers were mostly between 3 to 4 hours [1].

Most of the students (50%) accessed the internet between 5.00 pm to 9.00 pm (Fig. 5). Many students accessed the internet after 9.00 pm (25%). In total, the students who accessed the internet between 5.00 pm until late at night (after 9.00 pm) were around 75%. Very few (1%) accessed the internet in the morning before 9:00 am. In general, those who accessed the internet before 5.00 pm were only around 25% because students are busy attending lectures. Also, when the survey was conducted, lectures were still held physically (offline).

Internet programs or materials accessed mostly (40%) by students were browsing and downloading materials related to their courses, followed by accessing social media (25%) and watching movies (23%). Only about 15% of them accessed the internet for reading

news (Fig. 6). There seemed to be a tendency that students currently showed less interest in accessing public news or information. They tend to have more time to surf the internet to obtain information related to lecture materials. We did not differentiate between study programs and gender in this survey. As a comparison, another survey found that female students spent more time accessing online course materials, while male students spent mostly on games [1].

Students often found disruptions to internet connectivity at the ITB Jatinangor campus in equal portions, i.e., at 40% each. The disruption occurred several times, usually because of the fiber optic cable's breakdown, which connects ITB Jatinangor with the Ganesha campus in Bandung (Fig. 7).

In general, users gave opinions on internet reliability at the Jatinangor campus as fairly good, as respondents gave a three on a scale of a maximum of five. However, in general, the ITB campuses' reliability on the internet network at both the famous Jatinangor and the Ganesha campus is needed to be increased. Several webinars conducted using campus internet networks, not to mention at the Ganesha campus, were still unstable and frequently interrupted during the pandemic.

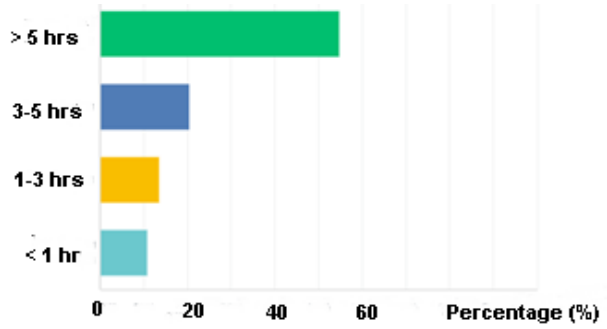

Figure 4 Duration (in hours) of students engaged on the internet on a typical day

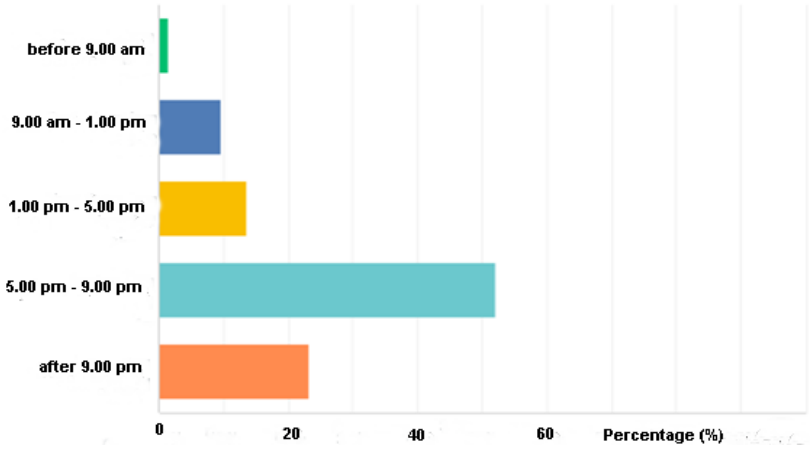

Figure 5 Preferable time students accessed the internet

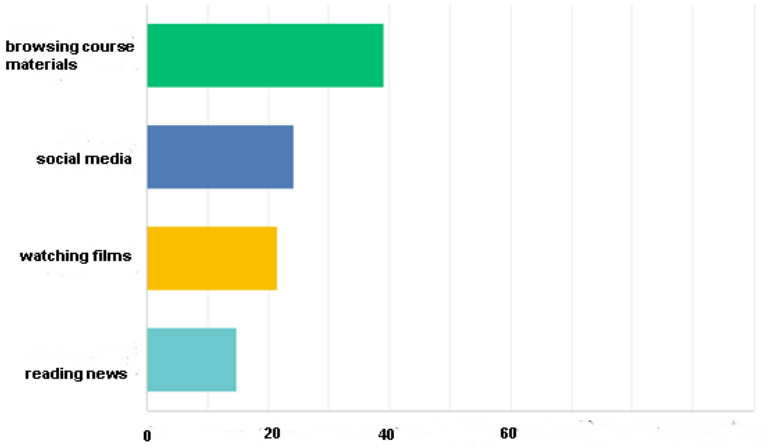

Figure 6 Internet programs or materials generally accessed by students

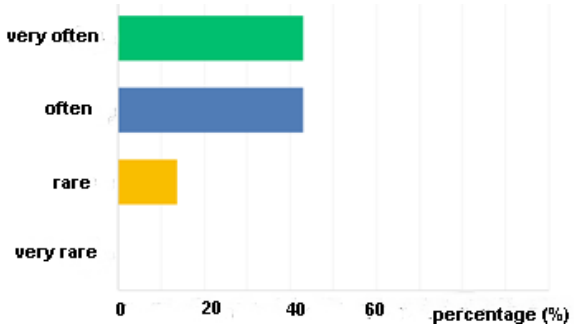

Figure 7 The frequency of disruption to internet connections at the ITB Jatinangor campus

3.6. Towards Smart and Green Campus

In general, internet reliability at the ITB Jatinangor campus is fairly good, already fulfilling the basic requirement for conducting teaching and learning activities virtually. The increase in the number of access points had taken place significantly, from only 10 access points in 2011 to 113 access points in 2015. There was an increase of more than 10 times in 4 years and became 144 access points in 2019. The addition of access points is very much related to the addition of students in the Jatinangor campus, closely related to the opening of new study programs and new buildings.

Spatial placement of access points on the ITB Jatinangor campus has also considered the academic community's internet access needs, especially students. Therefore, the placement of well-distributed access points on each dormitory floor becomes important. Besides, in the lecture room, administration building, and lecturer room, the internet's reliability on the ITB campus is very important. Based on the management office's surveys and reports, there are relatively few complaints related to the internet network's reliability at the ITB Jatinangor campus.

There are, however, some problems still found in internet reliability in the ITB Jatinangor campus. First is the disruption in connection due to a fiber optic problem that connects the Jatinangor campus to the main campus of ITB at Ganesha. The problem occurred because the fiber optic line that connects the Jatinangor ITB campus to the ITB campus in Ganesha was cut off several times by roadside excavation activities. ITB Jatinangor campus should have an alternative connection with the Sumedang area provider to overcome this problem in the future. Another problem is the disruption of electricity in both ITB Ganesha and ITB Jatinangor. Several times, power outages occurred at ITB Ganesha, resulting in an interruption in the internet network to the Jatinangor campus.

ITB Jatinangor campus area (43 ha) is twice as large as the ITB Ganesha campus area, with a much less (1/20th) student population than the Ganesha campus. Therefore, the availability of the internet in Jatinangor up to now is still relatively sufficient. Nevertheless, with the planning for ITB to transfer the TPB program to Jatinangor, there will be an addition of more than 4000 new students each year. The estimation is that the ITB Jatinangor campus students will significantly increase from around 2300 to around 5000-6000 population, a 3-fold increase. This forecast underlines the need to increase the capacity of the internet network as soon as possible.

Internet-based activities, including web-based classes, group projects, distance learning, e-mail discussions, and computer-based courseware distribution across the campus, all raise new issues about new adaptation and requirement of the educational process [6]. Moreover, lecturers will be challenged to find new ways to evaluate examination since intellectual privacy rights are very difficult to assess; university administrators will be challenged to find new ways to measure lecturers' performance and competence who use new teaching and internet-based learning processes [6].

Many colleges do not have decent classroom facilities to benefit from networked teaching environment's instructional opportunities. They may need to construct new types of classrooms where network access at every student desk in every classroom is completed with display and control equipment. Though this proposition is expensive, there still will be strongly felt needs for such facilities when faculty and students understand teaching and learning value in a networked environment [6]. The ITB Jatinangor campus has developed a basic internet reliability level in most classrooms and laboratories to some extent. Members of the campus faculty will expect the network to be constantly available and reliable.

In the future, the need for increased capacity and the reliability of the internet network at the ITB Jatinangor campus is very important, especially in the next one or two years ahead since the Covid-19 outbreak presumably remains. Therefore, lectures, laboratory activities, and administrative activities must be carried out virtually, and this began at the end of August 2020 for the academic year of 2020-2021. Planning for the installation and distribution of access points should also be linked to the concept of a green campus landscape, which is currently fairly good, with a cover of about 70%. Structuring the campus landscape needs to be added artistically with a garden that integrates integrated urban farming. Some closed gazebo covered with glass may be placed under plant canopy, equipped with electricity and internet access. A closed gazebo room is needed for the Jatinangor campus because snake populations are still found around the area.

In the campus internet planning process, several parties, including lecturers, students, and campus staff, should be asked for their opinions because they are internet service customers. Since every college is unique, every campus network may use a different approach to envisioning, planning, and building its campus network that significantly impacts campus functions. Therefore, it is important to have a wide involvement of all stakeholders in the planning process [4]. To meet this requirement, the ITB Jatinangor campus's management has conducted regular meetings with all head of study programs, besides daily communication via WhatsApp groups.

Moreover, there is a challenge that ITB Jatinangor campus should plan for a smart campus where IoT will serve the community. Internet of Things (IoT) holds an important position in the context of Information and Communication Technologies and the development of society, especially in higher education institutions. With the support of IoT, institutions can increase learning outcomes by providing more rich learning experiences, improved operational efficiency by gaining real-time, actionable insight into student performance [3]. IoT's application increases objects' capabilities and forms a smart environment [7,8], and it covers buildings, environment, public services, et cetera. [7,9].

In the future, many trends will possibly influence the future demand for spaces at universities. Online education, changing funding mechanisms, and life-long learning are a few of them. Furthermore, the recent coronavirus pandemic has shown to what extent unforeseen changes can disrupt the demand for space, and its effects are likely to impact the use of spaces at universities and many other places long after. With IoT applications in place, users of the current campus will be enabled to use the campus more effectively, and campus managers will be better positioned to assess the effects of these demands on space usage and adapt their campus strategies accordingly [10]. This demand is a challenge of the 4.0 Industrial revolution, which pushes the university to prepare and take action right away as campus lockdown continues. There are still plenty of rooms for the ITB Jatinangor campus with its current condition to be planned in IoT scheme to become a smart campus.

The concept of a smart campus nowadays has become more and more ubiquitous. Muhamad et al. [11] categorize smart campus definitions into technology-driven, smart city concept adoption, and organization or business process-driven. In the technology-driven, smart campuses evolve from the digital ones focusing on advanced infrastructure, while the adoption of the smart city concept puts the focus on the similarities between cities and campuses, supporting various users to perform multiple tasks in multi-functional buildings [12]. In organization or process-driven, the emphasis is put on optimization criteria such as implementing intelligence through the use of various sensor technologies automatically, including learning, social interaction, and intelligent building management [11]. Moreover, Galego et al. [13] emphasize the need for the human dimension in defining the meaning of "smartness". Some researchers have also underlined smart campuses as the environments where different ubiquitous learning systems have been deployed at the campus [14,15].

Planning for the smart campus of ITB Jatinangor must also consider a green campus (Figure 8) by maintaining and even increasing the tree canopy's closure to create coolness and reduce electricity usage in air conditioner use. Incorporating natural elements in the development of smart and green campuses requires careful planning that involves diverse expertise from IT, biology, regional planning, landscape architecture, civil and environmental engineering, et cetera. This concept needs to be supported by the management of ITB with adequate funding.

Hsing-I [16] proposes the steps and the architecture of how to construct a green campus by utilizing the advanced technologies smartly and adopts the concept of the "Internet of Things" to construct the green campus will realize the idea of energy saving. The objects of his work include computers and air conditioners. RFIDs and the ZigBee device with temperature modules are used to build up the wireless sensor network. The contributions delivered by the system include i) managing computer labs efficiently, ii) monitoring the use of computers to reduce the number of idle power-on computers, (iii) controlling air conditioners, only turning on when the temperatures reach a preset level in order to save more energy, (iv) combining the wireless sensor network and cloud computing, and (v) allowing users to connect to the system with any mobile device in any place [16].

The stages in realizing the smart and green ITB campus need to be made clear by exploring all alternatives and utilizing all available resources; thus, the funds must be spent efficiently and effectively. Some actions can already be started, such as reducing paper usage both for correspondence and documents. Currently, the Covid-19 pandemic has directed the campus to do all in soft (electronic) copies. In the future, student's theses seem to be no longer necessary in the form of hardcopy, which currently becomes a burden in the library and cramped lecturer rooms. Spacious artwork products may be made more functional by considering the burden on the environment, instead of just for the art's sake. Discussions with stakeholders involved in this context need to be carried out to ensure that everybody will satisfy, and the goal to create a smart and green campus becomes a reality.

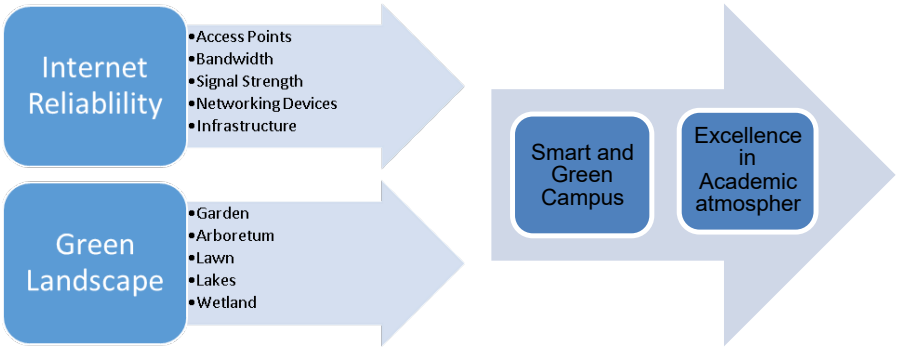

Figure 8 The need for internet reliability and a green landscape for implementing a smart and green campus to achieve excellence in the academic atmosphere

4. CONCLUSION

In general, internet reliability at Jatinangor campus is fairly good as respondents gave a score of 3 on a scale of 5. Interference with internet connectivity at Jatinangor campus often occurs due to unavoidable external factors, i.e., electricity and fiber optic disruption instability. Respondents (60%) accessed the internet for more than 5 hours every day, especially between 5.00 pm to 9.00 pm. Students accessed Wi-Fi from several places such as the student dormitory, lecture rooms, student's association office, library, and canteen. They used the internet mostly (40%) to browse and download material related to lectures, while the rest were mostly for social media, watching movies, or keeping abreast of the news. Besides the number of access points, internet access speed depends on the number of users connected to the internet, the allocation of available bandwidth, and the level of bandwidth consumption. During the Covid-19 pandemic, when lectures were conducted virtually, student interaction with the internet become more intense from morning to evening. A survey on the effects of lockdown on student internet activity needs to be carried out. A further questionnaire also needs to be asked about the behavior of students based on various study programs. Finally, realizing the concept of ITB Jatinangor campus as a smart and green campus needs the active involvement of all stakeholders in the campus as well as political will and financial support from ITB's decision-makers.

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