Northern Bukidnon State College

Computer Laboratory Management System: An RFID PC-Based Monitoring System for the Institute for Computer Studies' Laboratory at Northern Bukidnon State College

A Capstone Project

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Bachelor of Science in Information Technology

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APPROVAL SHEET

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ABSTRACT

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KEYWORDS:

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CHAPTER 1

THE RATIONALE

1.1 Introduction

Information technology (IT) is now an important part of higher education today and has served as the key to education efficiency, accountability, and innovation in either academic or administrative operations. In 2023, 65% of institutions in higher education are investing in more IT budgets in digital transformation, and half of them now use data analytics to enhance their operations, a tool that may be ported to raise performance levels in laboratory management (World Metrics, 2023). Over the last few years, 78% of higher education CIOs have treated digital transformation as a way of student success prioritization, and 73% of those consider it a high or essential prioritization to an institution (Workday Higher Education Outlook, 2023). Additionally, a 2023 EDUCAUSE report revealed that 72% of institutions experience fragmented data systems and assessing cross-departmental insights across the university is challenging, which can have severe negative effects on efforts such as efficient lab resource allocation.

In spite of this progress in adopting IT, monitoring of shared computer laboratories which is a key element in most academic programs, lacks sufficient utilization and in some cases is outdated. In other words, the previous solutions, like the *PC-Based computer laboratory monitoring system* developed by Lumawig and Payawal (2000) were based on strategies that are outdated and do not comply with the requirements of modern standards. Even in most institutions, administrators continue to rely on manual observation, ad hoc log retrieval and surveys, which are often not complete and may not be uniform. Such inadequacies deteriorate the chances of making sound decisions regarding the timing, software licenses, and hardware upgrading processes on the basis of correct and on-time information.

Education is one of the national development support, the pillar of national competitiveness in the global age. Within the Philippines, Republic Act No. 10599 and CHED Memorandum Orders require higher education institutions to have sufficient facilities and infrastructure such as libraries, laboratories and other specialized learning areas to permit established and sustainable learning conditions (CHED, 2021).

In Northern Bukidnon State College (NBSC), the Information and Communication Technology Management Office (ICTMO), acts as a significant factor in making this vision possible. The ICTMO believes in delivering innovative, competent, and dependable ICT solutions in order to meet the academic, administrative, and operational objectives of the institution. It aims to enhance the NBSC community through its provision of the state-of-art technology services, provision of secure and sustainable IT environment and initiation of digital transformation in all departments. It aims to facilitate hassle-free communication and boost digital learning and to help the college to attain excellence in education and service. But to effectively run the laboratory of the Institute of Computer Studies, it is more important than to maintain the machines to be in working condition. Administrators would really want to have fine grained, per-session statistics of what applications students are actually executing or the use of PC softwares such as CPU-Z and task manager to view the current status of the PC's ram and processor which are not logged in the computer but logged by the lab staff itself manually and what length of time machines are kept idle and how the CPU and RAM are utilized. In absence of these kinds of insight ineffective prioritization of hardware upgrade, scheduled shutdown, unwanted application and more can take place.

Also researchers have found that examining application usage trends allows system administrators to distribute software licenses more directly, avoid inventory shortages at high usage periods, and save on unused tools (LabStats, 2024). Additionally, the detection of non-academic usage of software during the laboratory classes may assist in supporting an academically oriented environment since studies have shown that the presence of distractions in the digital sphere may decrease student arousal and performance to varying degrees (Nguyen & Ma, 2024).

A technical Cebu college, college study reported in 2023 that old PCs regularly exceeded CPU and RAM limits during multimedia courses, which slows their workflows and the ability of, say, instructors to slash practice sessions (Santos & Lim, 2023). In the same area, a Malaysian polytechnic study in 2021 revealed that without automatic monitoring, sometimes the high-spec machines remained idle and when the demands were heavy on the low-spec machines, caused requests to be delayed, and resources to be wasted (Ahmad et al., 2021).

A laboratory monitoring system is presented in this research as an application used to monitor the computer laboratory of the NBSC. Application usage, per session uptime, and CPU/ RAM utilization by each workstation will be automatically tracked and stored with subsequent data relating to particular PCs' through the website dashboard. NBSC could achieve actionable insights through continuous monitoring at a high resolution machine that could instead of a manual check be generating actionable decision making as well as an improvement in lab efficiency and evidence-based academic and budgetary decisions.

1.2 Statement of the Problem

Although the use of information technology in the field of higher education is fast growing, there is ineffectiveness in the monitoring and control of the shared computer laboratories in most institutions around the world. Current systems, such as the PC-based solution by Lumawig and Payawal (2000), are old or were not implemented because of lower feasibility back then. Manual observation and post-usage surveys do not give full and timely data, so it is challenging to make decisions about removal of least used application, maintenance, and upgrades by the administrators (World Metrics, 2023; EDUCAUSE, 2023).

Misuse is also a problem that unmonitored laboratories have to deal with, such as illegal software installation and excessive non-academic use, which are not typically noticed (Chen et al., 2021; Tan and Ng, 2022). Another problem is energy inefficiency where idle computers may take up to 60 percent of overall energy consumption, which escalates the cost of operation and environmental implication (Kaur & Singh, 2021). In the absence of automatic monitoring of idle time, it is hard to implement energy saving policies like planned shutdowns.

The unequal access also contributes to the problem. Improper monitoring may lead to the overuse of some machines with high demand and leave some unused, leading to access limitation and increasing hardware degradation speed (Alvarez and Santos, 2022). In 2022, a study conducted by a Philippine state university estimated that application demand during peak hour in 2022 would be underestimated by 38% under the condition of manual tracking. The same situation was observed in Cebu and Malaysia, where the absence of automation created an imbalance with resources and delays in upgrades causing some pcs to have higher processing power than other(Santos & Lim, 2023; Ahmad et al., 2021). In higher education IT management, manual checking was identified as one of the biggest resources management challenges globally (EDUCAUSE, 2023).

In Northern Bukidnon State College (NBSC), the Institute for Computer Studies relies on laboratory's monitoring that is limited, and does not have the capacity to do the things mentioned in this study such as monitoring cpu activity in a bulk manner. To resolve these challenges, a web based PC monitoring system is required to offer continuous and information based insights. The system would assist in decision-making, boost cybersecurity, minimize energy waste, and ensure efficient and sustainable management of ICT resources.

1.3 Objectives of the Study

The goal of this research is to design and develop a PC monitoring system at Northern Bukidnon State College (NBSC) which is capable of giving accurate real time data regarding laboratory computer usage. In particular, the study is intended to:

- **Measure performance per-session** of all laboratory computers and capture and record CPU and RAM used on each machine.
- **Monitor the software used and opened** by the students in the laboratory sessions to determine licensing, its allocation, and the academic compliance, addressing potential cybersecurity and misuse concerns such as illegal software downloads, non-academic use, and malware exposure.
- **Keep track** of how much time is spent in sessions and idle with the labs to spot any inefficiency in using laboratory resources.

- **Include RFID technology** to associate the laboratory usage data with a particular computer to have secure and reliable tracking.
- **Create operation reports** that are useful in making evidence-based decisions.
- **Evaluate the system's effectiveness** in improving the accuracy, completeness, and timeliness of laboratory usage data compared to existing monitoring methods.
- **Estimate the electricity cost of idle laboratory computers** by calculating idle energy consumption and translating it into monthly power expenses, enabling administrators to identify potential savings through improved power-management policies.

1.4 Scope and Limitations of the Study

The research study is limited in the Institute for Computer Studies (ICS) laboratory of Northern Bukidnon State College (NBSC). The system development, deployment and evaluation will be feasible within the time, resources and technical limitations available.The study will only focus on desktop PCs but not on other devices such as laptop and mobile devices, as per reason as they have different operating systems, power consumption and usage patterns.

The study excludes other NBSC departments and off-campus settings to keep the project closely aligned with the immediate needs of the institution. The ICS laboratory is one of the most resource-intensive areas due to software licensing requirements and the demand for moderate to high-performance computing, which makes it the most relevant environment for testing the system. Although the system records application usage and performance data, it is not designed to perform full cybersecurity monitoring or track additional hardware metrics beyond CPU and RAM. These tasks would require specialized tools outside the scope of the project.

By setting these boundaries, the study maintains a focused implementation and a clear evaluation process, ensuring that its recommendations directly address the operational challenges currently faced by the laboratory.

Overall the system will be applicable only to the ICS laboratory area and will not include the other NBSC labs as well as off-campus machines. Laptops, mobile and devices will not be monitored, only desktop computers that will be connected to the local network. Since the application can run in a background mode, it will consume minor system resources, and constant running needs at least one computer to act as a server. The research is not intended to be used in the extensive monitoring in automated maintenance, or more parameters of other hardware sides such as Keyboard, Mouse, Cameras(if present), keylogs etc. It also does not monitor GPU-load and connection speeds.

1.5 Significance of the Study

The following are the beneficiaries of the system:

- **To the Laboratory Administrators and ICTMO Staff:** The system gives detailed and session-by-session trace logs and performance data, which can be used to schedule more efficient upgrades of hardwares in time and reduce downtime that is caused by the outdated hardwares that might try to run modern applications.

- **To the Faculty Members:** Having access to data on application usage and resource availability, the system will give the faculty clearer insight into whether the needed software is being used and whether laboratory computers are functioning well enough to support their classes.
- **To the Institutional Management:** The leadership in NBSC will have accurate insights to inform its policy-making decisions, budgets, and long-term ICT planning to ensure laboratory operations align with the overall objectives of the institution to become digital and environmentally sustainable.
- **To the future Researchers and Developers:** The research serves as a reference point for developing automated monitoring systems in academic laboratories and contributes to the growing body of knowledge on ICT resource management and practical educational technology innovations.

1.6 Definition of Terms

PC Monitoring System: The software and hardware infrastructure aimed to monitor and record the real time performance of the operational states of a desktop computer and its usage of applications.

Application Usage Tracking: Logging of software application opening, the number of times, and the length of time per session where this should provide information on which licenses should have applications and how academic license compliance should be monitored.

Per-Session Data: The records that have been made within one consecutive session of computer usage, such as the date and time of computer activity, application activity and hardware performance metrics.

CPU Utilization: The current amount of the computer central processing unit capacity that is in use. This work measures the amount of CPU used and evaluates the load on the system, and provides prediction of possible bottlenecks in performance.

RAM Utilization: The active part of the memory of the computer used in the process of the work. This indicator assists in building views about whether workstations are under-utilized or over-utilized.

Idle Time: The duration between the start and end of a computer with an idle, rather than active, state. Observation of idle time can be used to detect resource idle time and ineffectiveness.

RFID (Radio Frequency Identification): a technology that uses electronic tags placed on objects, people, or animals to relay identifying information to an electronic reader by means of radio waves.

System Uptime: The summed amount of time that a computer is running and powered up, between start up and shut down during a session.

Automated Logging: Automated data gathered about system performance and features, as well as application usage without being manually entered.

Dashboard: A main graphical interface that presents gathered data and analysis of all observed laboratory computers, which can support the administrators in making highly considered decisions.

Laboratory Resource Management: The design, provisioning and support of computing resources of a laboratory to maximize performance, availability, and cost-efficiency.

Software Licensing: Refers to the legal agreement that defines how software can be installed, used, and distributed. In this study, it pertains to ensuring that applications used in the laboratory are properly licensed and authorized for academic use.

Academic Compliance: The adherence of software and computer usage within the laboratory to institutional, ethical, and educational policies, ensuring that students use technology only for academic and research purposes.

Cybersecurity: The practice of protecting computer systems and networks from digital attacks, unauthorized access, or damage. It is relevant in monitoring software activities to prevent malware infections and data breaches.

Software Misuse: The inappropriate or unauthorized use of software, such as illegal downloads, installation of unlicensed programs, or using applications for non-academic purposes.

Malware: Malicious software designed to disrupt, damage, or gain unauthorized access to computer systems. The term is used in relation to cybersecurity risks in unmonitored laboratory environments.

System Integrity: Refers to the state of a computer system when its data, configurations, and operations remain reliable, uncorrupted, and secure from unauthorized changes or attacks.

Data Analytics: The process of analyzing data to find patterns and insights.

Illegal Software Installation: The unauthorized installation or use of unlicensed software.

Laboratory Computer/s: Computers used by students in the school's computer laboratories.

CHAPTER 2

REVIEW OF RELATED LITERATURE AND STUDIES

2.1 Related Literature and Studies

To better understand current developments and best practices, the proponents have reviewed a range of relevant literature that informs the design of a system for PC usage monitoring, asset tracking, and real-time management in a school laboratory setting.

PC Monitoring Systems

Academic labs use monitoring systems that track the use of software, session times, and logs of user activities to help understand the activity of students and the utilization of hardwares. These tools can assist in accountability as well as the strategic nature of software license agreements and systems hardware upgrade.

A significant problem lies in the missed insights that happen when monitoring is not applied throughout the campus. An article by Beth (2024) says that restricting monitoring to a single department or computer lab can result in a number of dangers. When it comes to hardware, an organization may purchase underutilized computers or fail to maintain computers that require IT upgrades. Additionally, this makes it more difficult for the organization to adapt quickly to shifting demands or financial limitations.

The issues are similar for software. A university runs the risk of paying for unnecessary licenses or duplicate programs if it doesn't have a thorough monitoring system. Additionally, it becomes more challenging to guarantee that every computer is running the most recent software versions, which can lead to compatibility and vulnerability problems. It is also difficult to defend software costs and stop resource waste due to this incomplete picture. This study emphasizes how a fragmented approach to monitoring prevents organizations from fully optimizing their IT resources by resulting in inefficiencies and a lack of data-driven insights.

One major issue is the disadvantages of manual lab system monitoring, according to a study published by Ijraset (2024). According to the study, using a physical logbook to record login and logout times is prone to human error, which can result in inconsistent and erroneous data. Furthermore, in a system where computers are only connected by a local network, there is no administrative oversight, allowing students to unsupervisedly participate in activities unrelated to their assignments. This manual method hinders the development of efficient administrative oversight in a lab setting and makes it challenging for lecturers to effectively monitor student activity.

Zhang et al. (2025) suggested a mixed system to include RFID, IoT, and AI technologies in order to provide tracking of assets in real-time scale, issues of auto-maintained alerts, and information about detailed use. Their studies promote the concept of having monitoring capabilities in institutional asset systems.

Nevertheless, the monitoring leads to the worry of the security of data and ethical use of these data. Upon its responsible implementation, there needs to be the reconciliation of institutional control and the user privacy rights, i.e. only authorised persons should have access to logs and the data may be used only to make some operational improvement.

RFID Technology in Educational Settings

Radio Frequency Identification (RFID) is a wireless communication technology comprising three major components namely RFID tags, reader and backend systems. RFID is getting more and more popular in education, being used in asset tracking, student attendance tracking and library book management in educational institutions.

Begmanov and Yenradee (2022) also demonstrated RFID use in an educational parameter, where about **100%** identification accuracy was achieved on the tags. They saved a lot of time that was needed to take care of inventory when using manual barcode processes. On the same note, Swedberg (2024) has noted that James Madison University has implemented RFID to track AV and lab equipment and save up to days of rep time with handheld readers.

RFID4U (2024) further said that RFID tags which are most suited on metallic surfaces enable bulk scanning and the real time tracking of assets, even without manual intervention, which is the reason why computer labs can have them. These applications illustrate the advantages afforded by RFID over the conventional systems of tracking assets such as using stickers or barcodes, which have to be scanned, and often deteriorate due to abrasion.

Asset Management and Inventory Systems

Effective management of IT resources is crucial as it determines efficiency of operations and accountability of the resources within an institution. The manual recording or the barcode system of using traditional inventory systems is more labour intensive and prone to error.

According to Odasco and Saong (2023), the inventory management system of a university had several major issues, despite the fact that it was operated digitally. In their study entitled Analysis of the Inventory Management System towards Enhanced University Service Delivery, they found that the problems of the process like missing unmatched records were not infrequent. In particular, the research brought out challenges in the monitoring of non-consumable items and lack of timely identification of the missing or misplaced assets. Such loopholes in the system made it difficult to deliver services on time, destroyed accountability and demonstrated that existence of a system on its own is not sufficient in ensuring effective management of inventory. Completely in line with the current research, the present study allows us to propose a more effective and precise tracking solution.

Inventory management was systematically reviewed by Munyaka and Yadavalli (2022). By charting the development from antiquated manual techniques to contemporary technological applications, their findings offered a historical perspective. The review emphasized that because of their vulnerability to human error and incapacity to deliver real-time data, traditional, manual tracking methods are frequently a significant cause of operational failure. This literature gives the current study a solid theoretical basis and emphasizes how important it is to abandon antiquated manual methods in favor of automated systems in order to achieve accuracy and operational efficiency.

A direct comparison of inventory management software and manual tracking was presented in a Skilloutlook (2025) article. It carefully listed the drawbacks of manual methods, including their inability to provide a continuous, real-time view of inventory levels, delays in data updates, and human error susceptibility (reported error rates range from 1% to 3%). According to the article, these restrictions may result in serious issues like overstocking or stockouts. These observations are extremely pertinent to the current study because they offer a convincing and measurable argument in favor of switching from manual logbooks and sticker labeling to an automated, digital system.

The function of inventory management in logistics and organizational success was examined in a Destro et al. (2023) study. The study made the case that poor inventory control, a frequent consequence of manual tracking, has a direct negative influence on operational effectiveness and may result in losses. Inventory was characterized as a "double-edged weapon," with an excess of inventory resulting in a loss of profitability and a lack of inventory leading to a loss of productivity. In order to maintain a healthy balance in resource allocation and prevent the negative effects of unreliable data, this research supports the current study by highlighting the necessity of a strong, automated system.

Comparing RFID with barcode systems in a controlled environment, Atkins, Sener, and Russo (2021) concluded that the RFID system is better in one way than the other: it suggests the real time tracking and eliminates the human error factor. Radiant RFID (2022) also cited a case study in one of the leading Ivy League medical schools that used a passive RFID system and saved at least **75%** of inventory time. The combination of the system with the already existing asset management software allowed automating the audit and the simplifying of the operations.

Manap et al. (2025) also designed an RFID based laboratory inventory system that showed real-time equipment state through a centralized interface provided by PC. This provides real time availability of assets that are in-use or awaiting-use, a virtual mandatory requirement in schools that provide computer labs.

Integration of RFID with Monitoring Software

Combining the RFID with PC monitoring software enables simultaneous hardware tracking and session tracking, which improves the real-time tracking and versatile control over operations.

Kefallinos and Pontikis (2023) developed an entirely automated RFID tracking platform based on readers that are fixed and services offered by the cloud-supported aggregation. They also set up a system that reduced manual handling and gave them constant feedback on the location and activity of assets, which is also what we hope to achieve in our project.

Wasp Barcode Technologies (2025) underlined the fact that this kind of integration eliminates mistakes when performing manual actions and makes it possible to check in/out the devices quickly. By matching the RFID log with system activity, close auditing and tracking of the device movement inside the laboratory can be achieved.

Institutional Technology Management

Colleges and universities are under pressure to organize the use of IT assets cheaply without overspending the budget. This will incorporate monitoring usage pattern, and hardware maintenance planning.

Aemilianum College Inc. (2023) is one of those companies that adopted an RFID-based lab management system with scheduling, authorization principles, and reporting of features. The system that they had enabled the lab managers to achieve control over access and inventory in an efficient way. We are also proposing an increment of RFID tagging each PC to maintain statistics of usage, monitor the system up-time, and to assist in making decisions regarding the deployment of software.

A problem in IT management for higher education institutions is the complexity of a decentralized environment, which can result in ineffective procedures and resource waste. A lack of centralized oversight and software silos result from universities' frequent establishment of numerous departments, each with its own software and user bases. It is challenging to keep track of who has access to what, for how long, and whether the organization complies with security regulations because of this fragmentation (Deepanjali, 2025).

Also, an insufficient IT Asset Management (ITAM) might lead to several issues, such as inaccurate asset inventories, poor lifecycle management, and budget overspending. The moving around of devices and patching irregularities in different departments give way to blind areas that undermine the general security of the institution. The absence of the strategic ITAM plan can result in non-compliance with regulations, the excessive consumption of the budget on resources with low utilisation levels and the vulnerability of sensitive information about students to possible breaches(Cordeiro, 2025).

Data analytics are known to facilitate these management practices as institutions are able to get a feel of the unused resources and also rationalize their budgetary adjustments. System logs and audit trails can also lead to accountability, less asset loss and compliance with the institutional policies.

Cost Reduction

One of the biggest challenges facing institutional IT management is the pressure to reduce expenses and optimize budgets. This will include planning hardware maintenance and keeping an eye on usage trends.

Implementing RFID solutions can result in a 10-15% reduction in labor hours for tasks related to inventory, per a Quinta.co.in report. As a result, companies can work with a more productive workforce and reallocate employees to other high-value tasks. A higher profit margin is made possible by the technology's improved traceability, which also helps to lower loss and shrinkage. Additionally, RFID helps avoid stockouts by giving real-time inventory visibility, which in one case study increased a sports apparel brand's revenue by 2.5 percent (Quinta, 2025).

According to a different report from the RFID Journal, a number of important factors influence the return on investment (ROI) of RFID in the supply chain. According to the study, early RFID projects demonstrated a 3-5% decrease in supply chain expenses and a 2-7% increase in revenue, indicating that these initiatives can yield a substantial financial return. The main advantages include greater inventory accuracy, which can result in 10–30% savings on safety stock; decreased shrinkage, with one estimate citing an average decrease of 18%; and automation, which lowers manual processes and labor costs in warehouses by 7.5% or more (Admin & Admin, 2024).

In the end, the adaptation of advanced asset tracking systems offers a comprehensive solution to these challenges. These technologies give IT managers the ability to make proactive decisions that minimize loss, maximize resource allocation, and guarantee compliance by giving them access to real-time data on asset location, utilization, and status. This change from reactive to proactive management allows for long-term, strategic financial planning for the institution's technology requirements in addition to direct cost savings from fewer replacements.

2.2 Synthesis of the Reviewed Related Literature and Studies

The reviewed literature gives a strong basis on the development of an RFID based system of monitoring PC usage, tracking assets and managing them in real time in a school laboratory environment. Its combined results constitute compelling evidence toward the viability and great advantages of the use of RFID technology over traditional manual or barcode-based methods.

The review of the available body of literature reveals the high and steady support of RFID-based solutions coupled with the centralized observation and analytics as a better method of traditional sticker- or barcode-based control of the assets within the educational computer labs. RFID has repeatedly been noted to offer greater read accuracy, faster speed, and the capacity to scan in bulk or near-real-time in empirical and industry reports (Begmanov & Yenradee, 2022; Swedberg, 2024; RFID4U, 2024) and comparative studies have identified that the technology can reduce manual error and speed up the audit process when compared to barcode/manual methods (Atkins, Sener & Russo, 2021; Radiant RFID, 2022). Inventory practice reviews also support the position that manual systems are prone to manual error and can lack real-time visibility and are therefore not suitable for dynamic institutional environments (Munyaka & Yadavalli, 2022; Odasco & Saong, 2023), and industry studies calculate the amount of labour and cost savings there will be due to the increased accuracy of inventory and automation (Quinta.co.in, 2025; Admin & Admin, 2024). Most importantly, the representation of integration in the literature indicates that RFID physical-tracking combined with PC monitoring software and cloud- or centralized dashboards can result in multiplied value creation, i.e. correlating device location and physical status with session records and software use logs can provide richer and actionable intelligence to license usage, maintenance scheduling, and utilization planning (Kefallinos & Pontikis, 2023; Manap et al., 2025; Wasp Barcode Technologies, 2025).

At the same time, other research notes that technology is not a silver bullet on its own: implementation decisions (which type of tag, where to place readers, and how to handle metallic surfaces) also have a material impact in practice (RFID4U, 2024; Radiant RFID, 2022), and without thoughtful interoperability and workflow design an RFID deployment can be a data silo recreated in a new form as opposed to its solution (Odasco & Saong, 2023). Ethical and privacy issues surrounding increased monitoring are also presented numerous times; authors urge governance implementations and that means usage limits, role-based access, and retention policies to ensure a balance between the requirements of the institutions and user rights (Ijraset, 2024; Beth, 2024; Zhang et al., 2025). Lastly, although there is a large body of case studies and accounts of time savings, accuracy improvements and other short-term outcomes, the literature indicates less experience and data on institution-wide, long-term reviews of total cost of ownership, behavioral impacts on users or long-term effects on procurement and academic practice, and future implementations should take note and report (Destro et al., 2023; Deepanjali, 2025; Cordeiro, 2025).

Collectively, the reviewed literature has been able to give a consistent rationale of an RFID based PC surveillance and asset management prototype in a college computer laboratory: The operational and financial advantages of RFID have been established, RFID integrates best with monitoring software and centralised analytics, its value is enhanced by integration, and effective adoption requires close attention to technical specification, integration with other systems and strong privacy and governance measures.

CHAPTER 3

METHODOLOGY

3.1 Research Design

3.1.1 Type of Research

This study uses a combined approach that integrates experimental research with a system development methodology. This combination allows the researchers to assess both the technical performance and the practical usability of a PC monitoring system in an academic laboratory environment.

The experimental component focuses on systematically testing the system’s accuracy and responsiveness. Network latency, software response time, and reliability of the monitoring functions are examined. These tests measure how accurately the system records session data, tracks application usage, and reports CPU and RAM consumption.

The system development component follows an iterative process. Both the desktop application and the web interface go through repeated cycles of design, implementation, testing, and refinement. Each prototype iteration is reviewed by the laboratory staff of the Institute for Computer Studies (ICS) at Northern Bukidnon State College (NBSC), ensuring that improvements are aligned with actual laboratory needs and workflows.

3.1.2 Data Gathering Procedure

The collection of data in this research will be done in two steps; acquisition of system-generated data and the server that will send the gathered data to the database.

Phase 1: System-Generated Data Acquisition

- **Installation and Configuration –** PC monitoring software will be installed in the ICS laboratory and configuration of IP addresses to connect to the server.
- **Controlled Trials –** Experimental experiments will be arranged to check the condition of the system after setting it in different conditions (e.g., tag log, set on different places, different number of users simultaneously, different session durations).
- **Data Logging –** Start/end PC sessions, applications logs, CPU/memory usage values, and system uptime shall be automatically recorded by the system. A cloud database will have all logs safely stored and will have traceability by event time stamping.
- **Performance Monitoring –** The network latency and data packet integrity between the client–side monitoring module and server–side database will be continuously observed and recorded during the test/trials.

Phase 2: Human-Centered Feedback Collection

- **Semi-Structured Interviews –** This was carried out to discern usability obstacles, integration problems, and functional advantages with lab administrators and technical employees.
- **Usability Testing –** The participants will be engaging with the system and the researcher will note any problem of navigating, errors processing, and incidences of disruption of their work.

Ethical considerations will be adhered by using informed consent, data confidentiality, and access to limited data.

3.1.3 Data Analysis Method

Quantitative Analysis

- **Descriptive Statistics** – Mean, median, and standard deviation will be computed for session durations, CPU and memory usage patterns, and system response times. These statistics help describe typical laboratory activity and identify unusual performance behavior.
- **Performance Accuracy Measurement** –The accuracy of automatically recorded session logs will be compared with manually recorded data. Accuracy will be expressed as a percentage, and any discrepancies will be reported as proportions.

- **Comparative Analysis –** Paired t-tests will be used to determine whether there are significant differences in time efficiency and error rates between manual tracking and the automated monitoring system.
- **System Reliability Metrics –** System stability will be evaluated by measuring downtime, missed logs, and data transmission errors such as packet loss. These indicators will show how consistently the system performs during actual laboratory use.

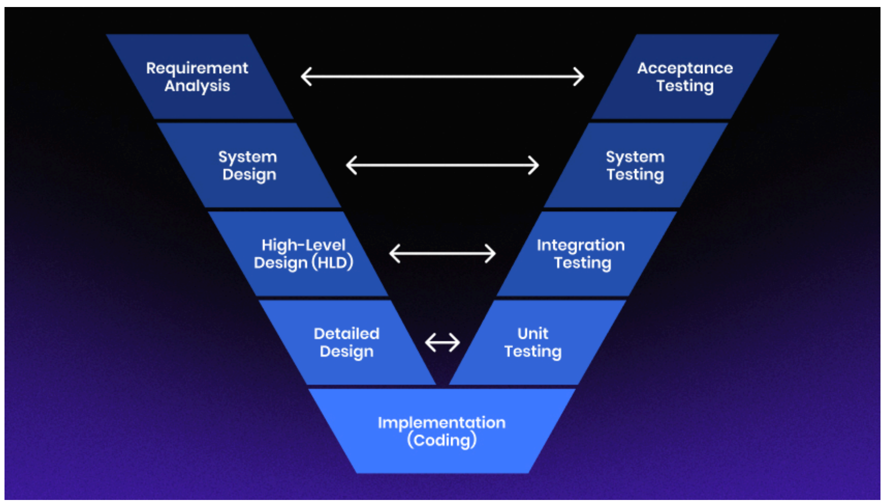
Qualitative Analysis

- **Thematic Analysis** – Usability feedback and transcribed interviews will be coded in order to find common patterns, issues, and suggestions on what could be improved.
- **Triangulation** – Qualitative data on performance will be balanced by cross-referencing quantitative performance data to provide accuracy in findings.

The dual analysis framework will allow the study to not only prove technical performance measures but also integrate the human dimension that will affect the adoption, usability, and sustainability of the RFID PC monitoring system.

3.2 Research Design Approach

In its study, a modified Systems Development Life Cycle (SDLC) with IoT-enabled and IoT-embedded systems will be used in adopting the V-Model framework. With this method, parallel verification and validation actions are undertaken on every level of development, and the requirements of functionalities and benchmarks of performance are always fulfilled.



Source: (*https://www.weetechsolution.com/blog/v-model-requirements-in-software-development*)

Figure 1. **V-Model Development Framework**

The development phases will include:

1. **Requirements Analysis** – Collecting the non-functional and functional requirements as a result of interviews, document analysis and observations in labs.

2. **System & Software Design** – Architecture, database schema, and dashboard analytics features of the system defining architecture.
3. **Prototype Development** – Designing a prototype working model of the monitoring software combined with the web based dashboard.
4. **Verification Testing** – Deployment to test technical correctness by means of unit testing, integration testing, and system testing.
5. **Validation Testing** – Conducting user acceptance tests on real laboratory personnel in order to ascertain that the system has conformed to real world requirements.
6. **Deployment & Feedback Loop** – Implementing the system in the ICS laboratory, gathering the data of its functioning, and adjusting the system according to the problems state or some feedback.

The presented **V-Model** based approach also lends itself well to mission-critical academic infrastructure, since it minimises deployment risk, achieves high reliability, and assures that the solution arrived at is technically sound as well as administratively feasible.

3.3 Hardware and Software Specification

The following are the hardware and software specifications of the project. These were requirements for the implementation and design of the application.

3.3.1 Hardware Specification for Development

The table shown below reflects the hardware components of the project during the development phase of the researchers.

Table 1. **Hardware Development Specification**

HARDWARE	SPECIFICATION
Processor	*Intel(R) Core(TM) i3 or equivalent @ 2.30GHz or higher*
Installed RAM	*8.00 GB or higher*
System type	*64-bit operating system, x64-based processor*
Storage	*1 GB SSD or higher*
Network	*Ethernet or Wi-Fi connectivity for client-server communication*
IOT	*NTAG213 Tags Ntag213 14443A RFID Tag 13.56MHZ 2*1cm*

3.3.2 Software Specification for Development

Table 2 discussed the software specification used to develop the system.

Table 2. **Software Development Specification**

SOFTWARE	SPECIFICATION
Operating System	Windows 10/11
Node.js	Version 16.0 or higher
Electron	Version 37.2.3 or higher
MySQL	Version 8.0 or higher
Code Editor	Visual Studio Code
Git	Version control system
WebSocket Library	ws version 8.18.3
Database Driver	mysql2 version 3.14.2
System Monitoring	active-win version 8.2.1, pidusage version 4.0.1

3.4 System Design Architecture

The diagram below presents the system design architecture of the PC Usage Monitoring System, which describes the operational mode and workflow of how the application monitors, records, and manages computer usage in real time.

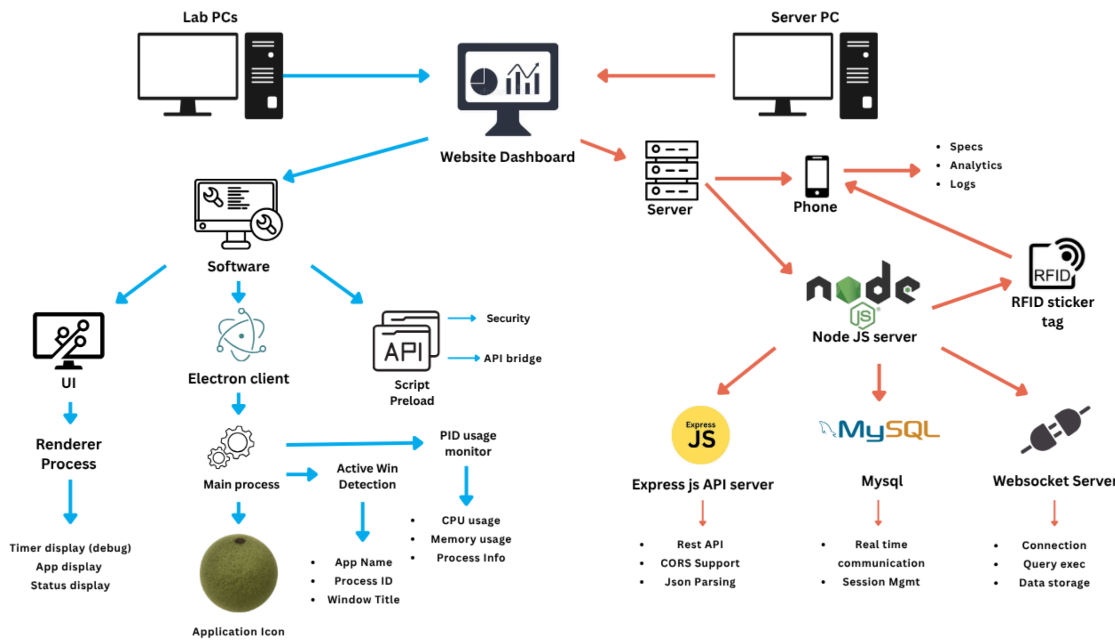


Figure 2. **System Design Architecture of PCUMS**

As shown in Figure 2, The system architecture depicts the fundamental elements, as well as the working process of the PC Usage Monitoring System. It describes the hardware and software architecture that is required for real-time monitoring of activity and data communications. The system will work with a number of machines, including client-side lab PCs and an Electron-based desktop application and a backend with Node.js.

The building is designed into two practical layers:

Front End

User interface (UI) provided by the renderer process of the Electron client, through which the user can see live data in the form of timers, states, statuses, and application states.

Back End

Back End is written in TypeScript by Electron main process, system monitoring scripts (e.g., PID usage, active window detection), and the Node.js server infrastructure that serves API requests, WebSocket traffic and MySQL interaction.

3.5 System Diagrams

Use-Case Diagram

The diagram below shows the use case of the application which depicts the interaction between the different actors and system components in a time-tracking and monitoring environment in a laboratory set up. It demonstrates the contributions of various roles to the entire functional system of the system with respect to administrative tasks, data management and user interface.

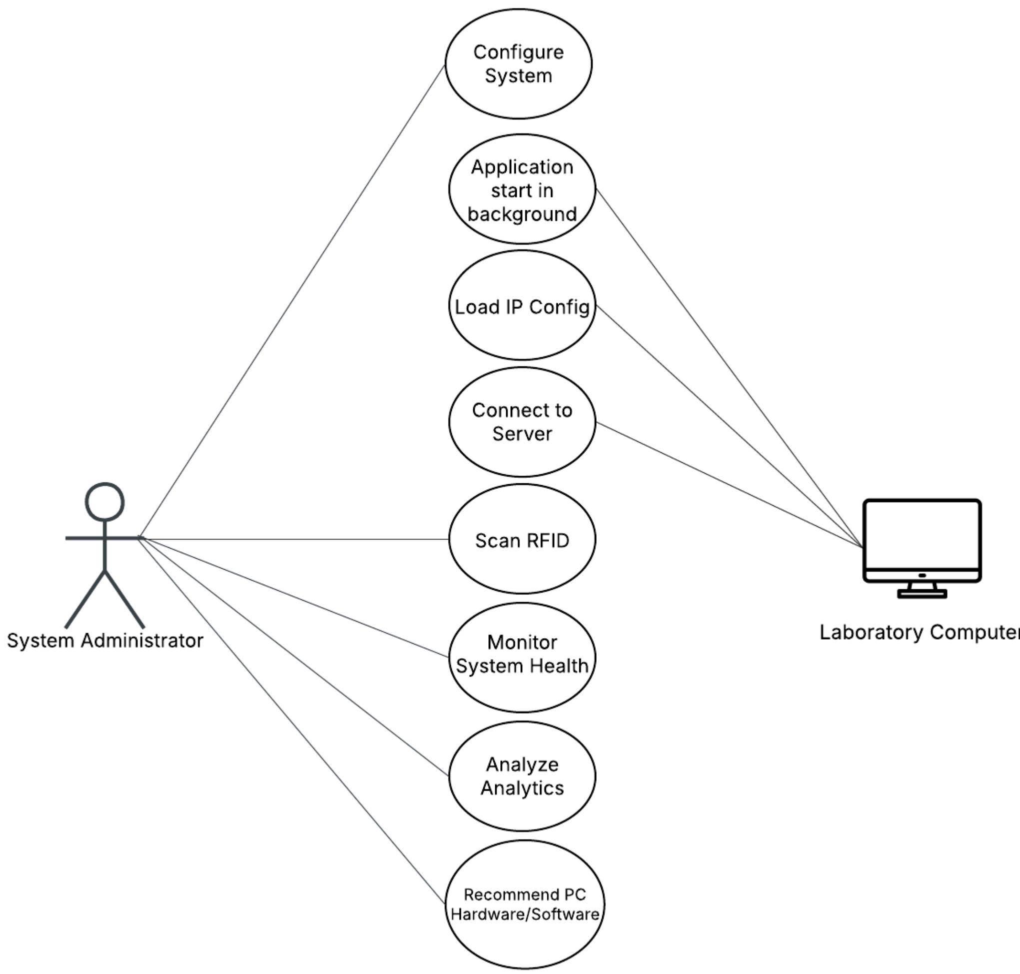


Figure 3. **Use-Case Diagram of PCUMS**

System Administrator

This user is tasked with high level control and maintenance of the system. This may involve: configuring the system, keeping an eye on the health of the system, generating analytics, user management, troubleshooting, and backup and restore. These are the actions which are lengthier or involve sub-processes such as granting API access, rectifying configuration problems, and system mistakes.

Laboratory User

Using the system is easily carried out by the Laboratory User by only switching the PC on. As soon as the session begins, their use will be recorded automatically in the background. The interface of the system has shown the timer and the session details, but the user would not have to make any additional input unless the user prefers to manually log out of the session.

CHAPTER 4

RESULTS & DISCUSSION

4.1 Overview

This chapter presents the results gathered during the allowed observation period. Two lab computers, ICSLAB2-PC19 and DESKTOP-BR15O2H were used to record real-time performance and application activity as well as session behavior. The system was used to measure CPU and memory usage, software usage and session behavior of two computers used in the laboratory. The analysis is aimed at determining the usage patterns, performance characteristics, and signs of efficiency or inefficiency. The results are discussed in relation to the aims of the study and the general problems expressed in Chapters 1 and 2, especially the necessity to have accurate and real-time data in laboratories.

The analyses in this chapter use descriptive statistical methods. These methods summarize and interpret data collected through the system and detail observable patterns and trends in CPU and memory use, software usage frequency, and session behavior. The results do not include hypothesis testing or inferential procedures. Instead, they offer a clear descriptive profile of laboratory computer usage during the monitoring period.

4.2 CPU Usage Trends

The system monitored the CPU activity at intervals during every day. Both computers had low to moderate base activities and increased hours of greater usage associated with particular tasks.

The largest spike was detected by ICSLAB2-PC19, which peaked at an average load of 52 percent, followed by DESKTOP-BR15O2H peaking at the same time with an average load of 24 percent. Earlier peaks at 22% and 48% coincide with the beginning of active sessions in which NetBeans or Packet Tracer were used.

Overall, DESKTOP- BR15O2H had lower average CPU usage of 6 to 24 percent across all periods than ICSLAB2-PC19's average of 8 to 52 percent. This shows higher computing that is pressing on ICSLAB2-PC19, and it agrees with some of registered sessions being simulation and development tools.

The results reveal that the system can track the CPU load change correctly in real time. These trends being captured gave the administrators a good understanding of when there is heavy activity on the resources (CPU and memory) and where these are more likely to be strained.

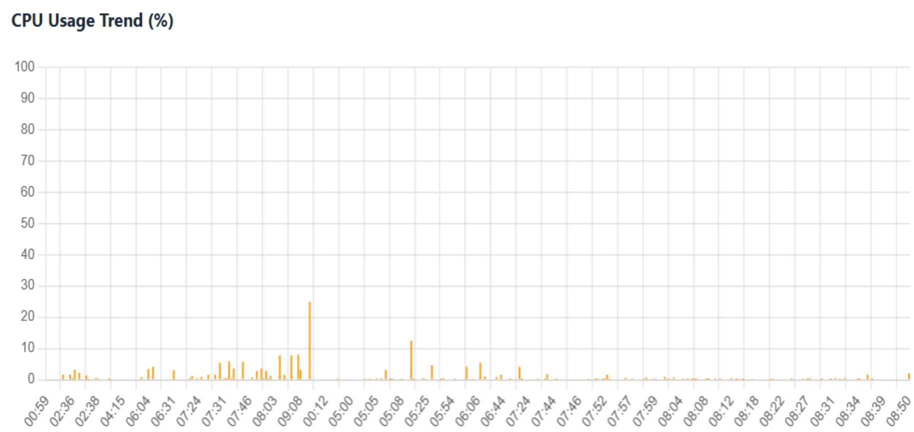


Figure 4. **CPU usage trends during the monitoring period.**

4.3 Memory Usage Trends

Memory usage remained constant at a low level during the morning activity. Significant increases appeared between 07:39 and 07:59 where ICSLAB2-PC19 topped up at 1.12 GB and DESKTOP-BR15O2H ended at 0.60 GB. Sessions involving NetBeans or Packet Tracer, which are known to use a significant amount of memory, coincide with these times.

ICSLAB2-PC19 presented the higher memory consumption that reached 1.00 GB several times, and DESKTOP-BR15O2H remained under of this value to a maximum of 0.60 GB. This increased load of ICSLAB2-PC19 corresponds to its hotter application profile.

The system's memory logs show that it can track how much memory is being used in real time. The data provides the possibility to identify problems and determine whether memory upgrades are necessary for specific laboratory units.

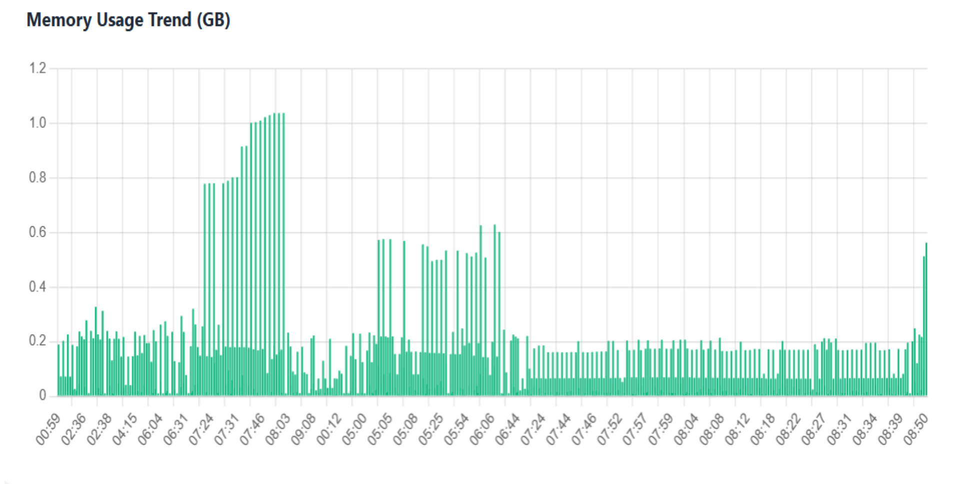


Figure 5. **Memory consumption the monitoring period.**

4.4 Application Usage Analysis

The application usage totals that have been recorded reveal a distinct pattern of academic activity on both computers. During the monitoring period, the most used applications were:

- Windows Explorer - 10.5 hours
- Google Chrome - 9.9 hours
- Packet Tracer Executable - 5.0 hours
- Apache Netbeans IDE Launcher - 2.6 hours
- Windows Terminal Host - 2.5 hours

Packet Tracer on DESKTOP-BR15O2H was used only for 0.8 hours, and ICSLAB2-PC19 shows almost double the value 4.2 hours, indicating that ICSLAB2-PC19 was used frequently for networking related assignments. On the other hand, DESKTOPBR15O2H had larger NetBeans activity with a value of 1.7 hours while IC-SLAB2PC19 was recorded at 0.9 hours indicating its frequent usage by students for Java programming and project compilation.

More lightweight system tools, such as LanSchool Student, Settings and XAMMP control appeared with minimal usage. These low totals indicate that students infrequently used these tools during the monitored period.

The results show that the system records detailed application use patterns, which is essential for curriculum planning.

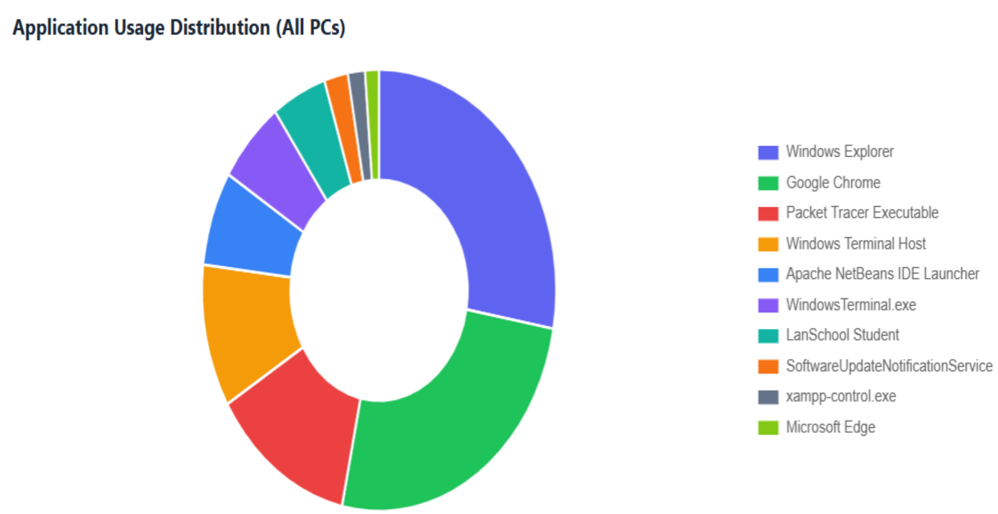


Figure 6. **Total application usage hours recorded for both laboratory computers.**

4.5 Laboratory Capability Contextualization

Based on the performance metrics, application usage totals, and session behaviors recorded in this study, it can be established that this laboratory is a General-Purpose Programming and Lan Simulation Laboratory. The usage of Packet Tracer, NetBeans IDE, Chrome for research, and Windows Terminal indicates a mix of programming activities, networking tasks, and general academic work typical of IT and Computer Science programs.

4.6 Estimated Electricity Cost Using CPU usage from Idle Time

We estimated the cost of idle time for the laboratory computers over a monthly period. We used the following assumptions and calculations:

1. The Intel Core™ i5-10400 CPU consumes **0.065** kWh when idle per hour.
2. From our monitoring data, we calculated that each PC averaged **80.52** hours of idle time per month, Saturdays and Sundays are not included.
3. If we estimate 20 PCs, the total idle energy consumption per month is:

0.065 kWh/h×80.52 h×20=104.68 kWh

4. We applied the current Meralco electricity rate of **₱13.47** per kWh. According to Meralco's latest rate adjustment, the rate for November 2025 is **₱13.4 per kW**h. We chose meralco for generalization and

the lack of data to NBSC's electrical power provider which is BUSECO.

5. Multiplying the total consumption makes the estimated monthly cost for 20 idle PCs:

104.68 kWh×₱13.47= ₱1,410 (approximately or more)

Keep in mind that this calculation is for the cpu voltage only and it does not include other peripherals such as PSU, Monitor, or the whole PC and other peripherals except the cpu.

4.7 Summary of Findings

The system successfully recorded and evaluated real-time data on CPU and memory usage, application usage, and session behavior on both lab computers. CPU and memory charts reflected increases as expected during programming and simulation workloads, especially when the applications Packet Tracer and NetBeans were active. These increases in resource consumption lined up with the academic instructions presented to ICS students.

Application usage revealed that Windows Explorer, Google Chrome, Packet Tracer, and NetBeans IDE Launcher were the most used applications, indicating a blending of file handling, web-based research, dummy networking simulation, and Java development. Session behaviour demonstrated that active usage times were much greater than idle time for most sessions. Certain sessions did exhibit a few instances of long, idle time periods, suggesting possible inefficiencies in workstation usage and the necessity for logout times, or the development of idle detection.

ICSLAB2-PC19 consistently registered a higher computational burden than DESKTOP-BR15O2H, as demonstrated by more CPU and memory usage. This is caused by a more regular incidence of simulation and development tools actively utilized on ICSLAB2-PC19. The system proved to effectively record structured performance data, supporting its application in operations, and resource management.

An energy consumption assessment using MERALCO's electricity rate of ₱13.27 per kilowatt-hour (as of August 2025) found that 20 laboratory PCs that have an average daily idle time of 3.66 hours (equivalent to a total of 18.3 hours of idle time for a Monday to Friday total of 5 days) would create a cost of nearly ₱1,410 to the school. More insight into the costs of unmanaged idle time are indicative of a clear financial motivation to support the implementation of energy-efficient policies that maximize laboratory usage.

These findings collectively support evidence-based laboratory management and reinforce the importance of real-time monitoring systems in optimizing resource allocation and overall efficiency.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary

The study monitored two laboratory computers at the Institute for Computer Studies (ICS) to evaluate CPU and memory performance, application usage, session behaviors, and idle-time electricity cost. The system captured real-time performance data and application activity, providing a clear view of how the computers were used during regular academic work.

CPU usage showed predictable increases during programming and simulation activities, especially when Packet Tracer and NetBeans were active. Memory usage followed the same pattern, with ICSLAB2-PC19 consistently reaching higher values than DESKTOP-BR15O2H due to more frequent simulation work.

Application usage results showed that Windows Explorer and Google Chrome were used for long periods, supporting file management and research workflows. Packet Tracer and NetBeans were among the highest academic applications used, confirming their role in networking and programming classes. Session logs revealed that active usage time generally exceeded idle time, although some sessions showed extended idle periods that pointed to possible inefficiencies in workstation practices.

The system also provided a basis for estimating electricity cost related to idle CPU time. Using Meralco's rate of ₱13.47 per kWh and an idle consumption model of 0.065 kWh per hour, 20 idle laboratory PCs could cost the school roughly ₱1,410 per month from idle CPU usage alone.

Overall, the system delivered accurate performance metrics and application-level insights that can support evidence-based laboratory management.

5.2 Conclusions

- **Objective 1**: The system successfully measured session-level CPU and RAM usage. Trends in resource consumption matched expected behavior during programming and simulation workloads, confirming the effectiveness of the monitoring process.
- **Objective 2**: The system accurately logged software usage across sessions. However, because the laboratory machines used for data collection did not contain paid or licensed applications, the study could not confirm whether the system can support license prioritization or budgeting decisions. The system can track usage patterns, but license-related insights require an environment that uses licensed software.

- **Objective 3**: Idle time tracking reveals periods of low activity that can lead to wasted energy. The system's ability to log both idle and active durations supports more efficient scheduling and the creation of policies that manage workstation behavior.
- **Objective 4:** The study demonstrated that session data can be tied to specific machines, supporting secure and consistent monitoring. Although RFID was not the main focus in the findings, the identification process functioned as intended.
- **Objective 5**: The operational reports generated by the system clearly summarized performance, application activity, and session duration. These reports can be used to inform decisions on scheduling, resource allocation, and hardware upgrades.
- **Objective 6:** Compared to manual monitoring practices, the system improved the accuracy, completeness, and timeliness of laboratory usage data. It produced structured logs that reduce the errors common in manual documentation.
- **Additional Conclusion on Electricity Cost:** The projected ₱1,410 monthly cost for idle CPU time highlights the financial impact of unmanaged idle periods. This supports the use of real-time monitoring to guide power-saving policies.

5.3 Recommendations

In light of the conclusions, the researchers recommend the following features for improvement, scalability, and institutional adoption:

1. Temperature
2. GPU
3. HDD/SDD
4. Search history
5. Real time data on power consumption
6. Implement automatic power saving when it detects idleness
7. Deployment of this or similar application in a larger scale
8. Deployment of the system in a laboratory that uses licensed software
9. Integrate alerts for abnormal performance
10. Evaluate the system in multiple types of laboratories

5.3.1 System Enhancement

1. Expand deployment to all ICS laboratory computers.

Continuous data from more units will yield better insights and allow administrators to observe broader usage patterns.

2. Implement automated idle logout and power-saving features.

Automatic session termination after prolonged inactivity will improve energy efficiency and free workstations for active users.

3. Add support for GPU monitoring and disk utilization.

As course requirements evolve, tracking additional performance metrics will help identify early signs of hardware degradation.

4. Integrate user authentication for session-level identity.

While the current system tracks computers, adding RFID or institutional login for users can provide per-student analytics and accountability subject to data privacy policies.

5.3.2 Administrative and Policy Recommendations

1. Use system data to guide software license allocation.

Applications with low usage can have fewer licenses renewed, while high-usage software may require additional purchases.

2. Optimize laboratory scheduling based on peak usage times.

Performance spikes and session patterns can indicate when instructional or open-use periods should be adjusted.

3. Use data to plan hardware upgrades strategically.

Machines such as ICSLAB2-PC19, which show consistently higher workload, may be prioritized for RAM or CPU upgrades.

4. Promote responsible usage through policy reinforcement.

Use system logs to identify and minimize non-academic activities that may affect productivity or licensing compliance.

5.3.3 Future Research and Development

1. Investigate full-campus monitoring integration.

   Replicating the system across multiple departments will enable institution-wide analytics and resource planning.

2. Study long-term trends using expanded datasets.

   A semester-long observation can reveal seasonal patterns in laboratory use, student behavior, and hardware performance.

3. Explore machine learning integration.

   Predictive models could forecast hardware failures, optimize lab schedules, and detect unusual activity.

5.4 Final Statement

The development and implementation of the Laboratory Monitoring System mark a significant step toward modernizing laboratory operations in the Institute for Computer Studies at Northern Bukidnon State College. The system provides clear, accurate, and actionable data that supports improved decision-making, enhances resource management, and strengthens academic support processes. With proper adoption and continued refinement, the system has the potential to serve as a model for automated laboratory management in higher education institutions.

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