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Development of a barcode-based inventory system for AMT laboratory tools at PhilSCA, Metro Manila, Philippines

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A B S T R A C T

This study was conducted to evaluate the effectiveness of barcode system for tool monitoring and inventory management in a laboratory environment; to improve productivity among students, teaching staff, and non-teaching staff while promoting a sense of responsibility. The developed and tested barcode system saved time, minimized errors, and enhanced technological learning in tool transactions. The 80 participants involved in this study were from the AMT program at Philippine State College of Aeronautics, including 1st and 2nd year students, faculty instructors, and AMT tool keeper. Mixed-method approach was employed. Demonstration of barcode system initiated the participants to evaluate and provide feedback regarding its usage and benefits, which was assessed using Likert scale. Statistical treatments (frequency and percentage distribution, weighted mean, and independent sample t-test) were utilized for analysis. The barcode system surpassed participants' expectations, and met requirements for tool monitoring and inventory. Participants strongly agreed on the system being accurate, technologically advanced, and cost-effective. Implementing the system can enhance borrower tool keeper accountability, and improve transaction convenience and efficiency. These findings suggest that replacement of manual process with barcode system is highly recommended despite the need to improve security measures. The results could be used in proposing improvements and effective implementation for the current tool monitoring system in the AMT laboratory. Overall, this research showed benefits of implementing barcode system for the students, teaching, and non-teaching staff. Implementing barcode system would allow the institution to equip students with knowledge and experience through advanced technology aligned with the practices in aviation industry.

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RESUME

Este estudo foi conduzido para avaliar a eficácia do sistema de código de barras para monitoramento de ferramentas e gestão de inventário em um ambiente laboratorial; visando melhorar a produtividade entre os alunos, professores e funcionários não docentes, enquanto promove um senso de responsabilidade. O sistema de código de barras desenvolvido e testado economizou tempo, minimizou erros e aprimorou a aprendizagem tecnológica nas transações de ferramentas. Os 80 participantes envolvidos neste estudo eram do programa AMT da Philippine State College of Aeronautics, incluindo alunos do primeiro e segundo ano, instrutores do corpo docente e o responsável pelas ferramentas do AMT. Foi empregada uma abordagem de método misto. A demonstração do sistema de código de barras iniciou os participantes a avaliar e fornecer feedback sobre seu uso e benefícios, que foram avaliados usando a escala Likert. Tratamentos estatísticos (distribuição de frequência e percentual, média ponderada e teste t independente de amostras) foram utilizados para análise. O sistema de código de barras superou as expectativas dos participantes e atendeu aos requisitos para monitoramento de ferramentas e inventário. Os participantes concordaram fortemente que o sistema é preciso, tecnologicamente avançado e econômico. A implementação do sistema pode aprimorar a responsabilidade do responsável pelas ferramentas emprestadas e melhorar a conveniência e eficiência das transações. Essas descobertas sugerem que a substituição do processo manual pelo sistema de código de barras é altamente recomendada, apesar da necessidade de aprimorar medidas de segurança. Os resultados poderiam ser utilizados na proposição de melhorias e implementação eficaz para o sistema atual de monitoramento de ferramentas no laboratório AMT. No geral, esta pesquisa demonstrou os benefícios da implementação do sistema de código de barras para os alunos, professores e funcionários não docentes. A implementação do sistema de código de barras permitiria à instituição equipar os alunos com conhecimento e experiência por meio de tecnologia avançada alinhada com as práticas na indústria da aviação.

Keywords:
Inventário, rastreamento, aviação, inovação, escaneamento

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Introduction

Monitoring and inventory management systems are essential for businesses, particularly for those that heavily rely on inventory. These systems allow users to efficiently track inventory levels, provide accurate information, and maintain a record of items.

The aviation industry has undergone significant development in recent years due to the advancement of modern technology and the digital era. The rapid development of modern technology has significantly increased the amount of data and technological innovations that have become standard in the aviation industry. These advancements have transformed the way operations are conducted, with digital manuals replacing traditional paper, and innovative ways established for borrowing, tracking, and monitoring resources. Furthermore, according to Castilla (2023), an advanced fleet of aircraft will necessitate modernized monitoring and inventory management procedures to keep pace with the aviation industry's best practices, especially regarding resources. The efficiency of airlines and maintenance operations could be severely affected by issues with inventory and monitoring systems.

One of the primary issues with inventory and monitoring system in school laboratories, such as Philippine State College of Aeronautics (PhilSCA), is the inadequate tracking of tool and equipment. As a technical school, PhilSCA possesses a comprehensive collection of tools and equipment necessary for students to acquire and enhance their skills and competencies. However, manually managing and monitoring these resources can pose challenges. Many laboratories use manual methods of inventory tracking, such as spreadsheets or logbooks, which are time consuming and prone to errors. These methods can lead to missing or misplaced equipment, expired or insufficient precision tools, and or inaccurate records. As a result, laboratory tasks can be disrupted, activity may fail, and safety risks may arise.

The lack of proper tool monitoring and inventory system causes the tool keeping in the AMT laboratory to be often overlooked. Students experience conflicts in borrowing the tools and equipment that they need, leading to long queuing lines which delays their laboratory activities. Furthermore, missing tools, broken equipment, and uncalibrated precision measuring tools are common problems that have never been addressed. According to Karanikas et al. (2018), insufficient and limited resources, such as time, knowledge, and tools, have a significant effect on individual performance and may have negative outcomes like safety incidents and poor output. In a study conducted by Wynn (2021), manual inventory system causes lack of traceability in inventory movement, stunts efficiency, and causes inventory errors which led to increased expenses and financial loss. Hence, improvement in the efficiency and sense of responsibility of the students is needed.

In order to address the challenges associated with tool inventory and monitoring, the researcher proposes utilizing a barcode system. Employing a barcode system can yield numerous benefits. Additionally, it reduces the likelihood of tool loss, damage, or

misplacement. It furnishes precise and current tool information, simplifying borrower tracking and availability monitoring. Additionally, it reduces the likelihood of tool loss, damage, or misplacement, thereby enhancing overall management. Lastly, it streamlines tool management, freeing up time for instructors and students to focus on other priorities.

According to Istiqomah et al. (2020), implementing a qualitative technique that demonstrates how this barcode system can improve productivity in warehouse management is instrumental in streamlining processes like receiving shipments, processing inbounds and outbound orders effectively, while also ensuring efficient stock checks. Barcode system for tool monitoring and inventory, draws inspiration from the valuable ideas presented in the Capstone Guide journal (2020). The concept discussed in the journal is essential as it served as a foundation for the development of this research. Ali et al. (2022) stated that various automatic identification technologies, such as RFID and barcodes, have gained popularity as trends in recent times. This article aligned with the present researcher's perspective, emphasizing how current and innovative technologies have become common and influential in driving industry improvements and growth; Chucks et al. (2020); Sheikh et al. (2019); Bing and Yang (2019); and Al-Momani et al. (2020); wherein the researchers have proven that the efficiency, reliability, and convenience in inventory management is greatly enhanced by utilizing an automated systems and barcode system rather than using traditional manual methods. Similarly, in the context of warehouse monitoring, Hamdy et al. (2018) concluded that implementing Warehouse Management System (WMS) enables real-time visibility of all warehouse operations, leading to improved speed, efficiency, and proactive prevention of inventory shortages and counterfeiting. In an article by UNFPA Philippines (2019), the application of Barcode Technology through the Track and Trace Project was highlighted as a cost- effective solution to the problem of traditional pen-and-paper method of monitoring system that hinders real-time, accurate, and complete data for monitoring and inventory system of family planning service.

The studies reviewed by Tahil (2022), Diaz et al. (2021), Panganiban et al. (2020), Torres et al. (2021), and Bhasin (2019), cited in Cordial (2020), highlight the significant benefits of integrating technology into inventory systems, such as increased efficiency, cost reduction, and improved accuracy. These findings relate directly to the current researcher's study, which aims to enhance inventory management in the AMT laboratory tool room through the use of barcode systems. Similar to Tahil's emphasis on technology for saving time and reducing errors, the proposed barcode system in this research seeks to streamline tool tracking and minimize human error. Like Panganiban et al.'s work on improving inventory control and sales tracking, the current study aims to provide a more efficient way of managing tools in the lab, ensuring accuracy and reducing delays in tool availability. Additionally, just as Torres et al. (2021) discuss the benefits of eliminating repetitive tasks, the barcode system in this

research seeks to automate processes to reduce manual effort in tracking tools, improving overall efficiency.

The system proposed by the researcher offers several benefits, including reducing workload by providing an easy and convenient method for data collection. By scanning the barcode on both the tool and the identification of the borrower (whether they are a student, faculty member, or tool keeper), important information such as the tool's status, borrower details, as well as borrowing date and time can be recorded and saved.

The developed software for barcode tool monitoring and inventory system utilized python as the programming language. Python is a high-level, interpreted programming language known for its simplicity, readability, and versatility. Python emphasized code readability and used indention and whitespace to define code blocks, making it easy to understand and write. The dedicated software offers a range of features, including enhanced security measures. When borrowing or returning tools, the system requires scanning of the barcode registered for each tool and barcode registered for each ID of the borrowers and tool keepers to record the transaction. Only the authorized tool keeper is granted access for logging in and out. The main dashboard displays various details such as the list of the available tools, the number of registered borrowers (students and faculty), and tool keepers in the system. It also keeps track of the tool borrowing transactions with accurate dates and records of any unreturned tools. The software allows for easy registration of new tools, students, faculty and tool keepers. Additionally, it enables the generation of barcodes for efficient management. Lastly, the software includes key functions that allow the tool keeper to clear data, as well as import and export data.

The purpose of this research is to develop a barcode system for effective inventory and monitoring management that aims to help students and faculty to borrow tools easily in a hassle-free manner without consuming too much laboratory hours. It also allows the tool keeper to easily track the borrowers as well as the status of the tools. The possibility of the tool keeper receiving broken tools without knowing who is accountable for the damage is lessened.

Conceptual Framework

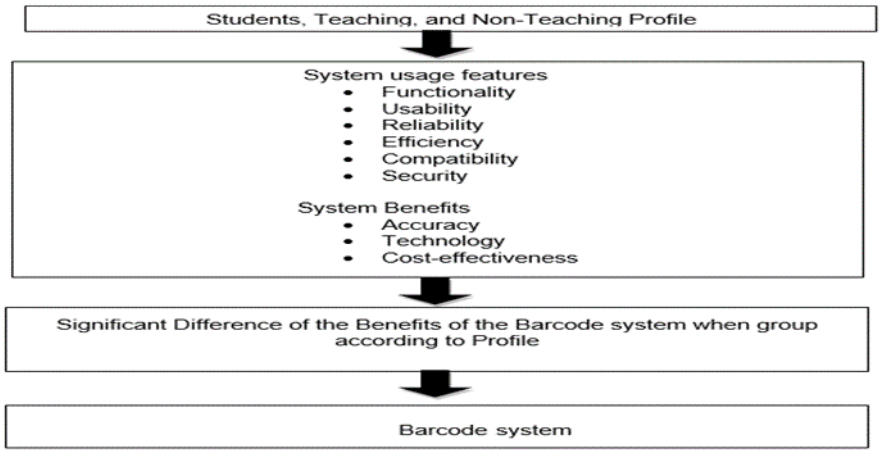
The study collected data from three different profiles: students, teachers, and non-teaching staff. The focus was creating an adaptable barcode system responsive to various user communities. Significant elements such as practicality, simplicity, resilience, effectiveness, coordination, and security were probed during development. These elements were carefully built into the design to guarantee that the barcode system met the different needs of its intended end-users. After collecting the participants' data, the study analyzed the benefits of the barcoding system according to different user profiles. The findings revealed that perceptions of the system's benefits did not change considerably across groups. The

development of the barcode system was created while taking into consideration the inputs and preferences of all user profiles. Considering the different functions and strengths required by different participants, the system is customized as an efficient tool for precise data acquisition and processing in AMT laboratories.

The collection of data used in this study provides useful insights into the needs and expectations of students, teaching, and non-teaching staff, and these feedbacks or insights contributed a lot to the development of this barcode system with all the important features and benefits to efficiently cater to all the needs of the users. The development of this barcode system shows the importance of considering user feedback and preferences to successfully establish it since they are the ones who will utilize it.

Figure 1.

Conceptual Framework Research Paradigm



Materials and Methods

This research utilized a mixed method approach, whereby the researcher gathered and analyzed both quantitative and qualitative data within the same study. This method is the most suitable approach for evaluating the functionality, compatibility, security, efficiency, reliability, and usability of the barcode system of tool monitoring and in inventory in the AMT Laboratory department at the Philippine State College of Aeronautics.

The sampling techniques utilized includes survey questionnaires and key informant interviews (KII). These methods aimed to gather information about participants' experiences and observations regarding issues with the barcode system. The objective is to enhance the efficiency of tool monitoring and inventory process in the AMT laboratory tool room.

This study is comprised of eighty (80) participants in total. All eighty (80) participants responded to the survey questionnaires, and ten (10) of them also participated in the key informant interviews. The participants were solely from the AMT department of Philippine State College of Aeronautics for the school year 2023-2024, which was composed of AMT students, faculty members, and the laboratory tool keeper.

Prior to data collection, the survey questionnaire underwent reliability and validity testing to ensure that the instrument consistently measured the intended concepts and produced accurate results.

The researcher sought approval from the Institute of Engineering and Technology Dean, and Aircraft Maintenance Technology Program Coordinator before conducting the intervention on the samples.

The researcher constructed questionnaires utilizing a four-point Likert scale for the survey and a Key informant interview (KII) as the data gathering device. The survey and interview questionnaires needed for the study were adapted from the research of Castilla (2023), and also utilized the ISO 25010 as a guide. The survey questionnaire is divided into two sections. The first section of the questionnaire collects the designation of the participant whether they are student, faculty and tool keeper members. Second, the participants underwent actual demonstration of the barcode system. The participants were presented with Likert-type questions or statements along with a range of response options, typically four (4). Each response option is assigned a numerical score, enabling quantitative analysis of the data. Feedback and suggestions were also gathered from the response of the participants through face-to-face and semi-structured interview. The response of the participants was then interpreted through qualitative analysis.

The response of the participants to the survey questionnaire were tallied, tabulated, and sorted carefully. In order to present, evaluate, and interpret the data; weighted mean, frequency counts, and percentage were used. In terms of the presentation, analysis, and interpretation of the data, weighted mean and independent sample t-test was used. Moreover, four (4) point Likert Scale was used to measure opinions, attitudes, or behaviors, and interpreted based on the table below.

Table 1.

Four Point Likert Scale Barcode System Usage Effectivity and Benefits

Unit Weight	Equivalent Weighted Points	Interpretation / Scaled Responses	
4	3.25 – 4.00	Highly	Functional; Usable; Reliable; Efficient; Compatible; Secure Accurate; technological; cost-effective
3	2.50 – 3.24	Functional; Usable; Reliable; Efficient; Compatible; Secure Accurate; technological; cost- effective	
2	1.75 – 2.49	Less	Functional; Usable; Reliable; Efficient; Compatible; Secure Accurate; technological; cost-effective
1	1.00 – 1.74	Not	Functional; Usable; Reliable; Efficient; Compatible; Secure Accurate; technological; cost-effective

Results and Discussions

The researcher used appropriate statistical treatments like frequency, percentage, weighted mean, and independent sample t-test to determine the result of the study. Data analyses were done according to the research objectives and research questions of the study. These are presented in the following tables with their corresponding finding and implication.

It shows that there were a total number of 80 participants from the AMT students, teaching and non-teaching staff. These 80 participants were assigned to undergo actual demonstration of the barcode system with basic tools and sample barcoded ID of student, faculty and tool keeper.

Table 2

Frequency and percentage distribution of designation of the participants

Designation		Frequency	Percentation %
Valid	*Student*	*70*	*87.5*
	Teaching & Non-Teaching Staf (Tool Keeper)	*10*	*12.5*
	Total	*80*	*100.0*

Out of 80 participants, 70 were students (87.5%) and only 10 were teaching and non-teaching staff (12.5%). This study suggests that majority of the users were students, with significantly higher proportion of student participants compared to teaching and non-teaching staff participants.

Table 3

Mean distribution of the participants' description on the barcode system in terms of functionality

FUNCTIONALITY	N	Mean	Std. Deviation	Rank	Interpretation
1. The system accurately records tool information, such as descriptions and quantities.	80	3.55	.54888	1	Highly Functional
2. The system offers backup and the ability to import and export data.	80	3.45	.59321	4	Highly Functional
3. The systems' barcode scanning feature has the ability to automatically store data.	80	3.46	.54988	3	Highly Functional
4. The system provides reliable and consistent functionality for tool monitoring.	80	3.52	.55060	2	Highly Functional
5. The system enables the generation of barcodes for efficient tool management.	80	3.45	.54888	5	Highly Functional
General Weighted Mean	80	3.48	.48870		Highly Functional
Valid N (listwise)	80				

Table 3 shows that the average functionality of the barcode system is 3.48 indicates that the majority of participants strongly agreed that the system is highly functional and effectively meets their needs and expectations for tool monitoring and inventory management in the AMT laboratory. Looking at the table, it shows that the systems functionality in accurately recording tool information, such as descriptions and quantities, rated highly functional with a mean rating of 3.55 followed by the functionality in providing reliable and consistent tool monitoring with a mean rating of 3.52. The other three functionalities related to the system's barcode scanning feature, including automatic data storage, backup options, data import and export, and barcode generation for efficient tool management, also received commendable mean ratings ranging from 3.45 to 3.46. The data indicates that the barcode system demonstrated in the AMT Laboratory received positive evaluations from participants. It was seen as highly functional, accurately recording tool information, providing reliable monitoring, and offering useful features for efficient tool management.

The system was considered a significant improvement over the traditional paper- and-pen method. Although the other three functionalities related to the system's barcode scanning features, such as automatic data storage, backup options, data import or export, and barcode generation, were positively received the slightly lower mean ratings (3.45 to 3.46) were linked to minor issues noted by participants. These include occasional scanning glitches, challenges in adapting to the data management functions, or limited flexibility to customize features according to specific user requirements.

Table 4

Participants' mean ratings of barcode system usability.

USABILITY	N	Mean	Std. Deviation	Rank	Interpretation
1. The system offers a user-friendly interface that simplifies the process of checking in and checking out of tools.	80	3.56	.52395	1	Highly usable
2. The system allows users to recognize if it is appropriate for their needs.	80	3.32	.65168	4	Highly usable
3. The system protects users against making errors.	80	3.32	.65168	5	Highly usable
4. The system requires minimal knowledge to effectively operate tool borrowing transactions.	80	3.48	.52756	2	Highly usable
5. The system has attributes that make it easy for the user operate and control the system.	80	3.48	.50300	3	Highly usable
General Weighted Mean	80	3.43	.47317		Highly usable
Valid N (listwise)	80				

Table 4 presents the weighted average mean of the participants' evaluation on the system's usability is 3.43 which indicates that the system is rated highly in terms of usability. The statement "The system offers a user-friendly interface that simplifies the process of checking in and out of tools" received the highest mean score of 3.56, ranking first. The second

and third statements, "The system allows users to recognize if it is appropriate for their needs" and "The system protects users against making errors," obtained lower mean scores of 3.32. The fourth and fifth statements, "The system requires minimal knowledge to effectively operate tool borrowing transactions" and "The system has attributes that make it easy for the user to operate and control the system," both received a mean score of 3.48, ranking second and third, respectively, with the same rank. The data indicates that the barcode system demonstrated in the AMT Laboratory is highly usable according to participants' evaluations. The system's user-friendly interface simplifies the checking in and out of tools, making the monitoring and inventory management process easier for users. However, participants showed relatively weaker agreement with statements related to recognizing appropriateness and error protection because participants were not as convinced or satisfied with how well the system allowed them to determine if it was suitable for their needs and how effectively it protected them against making errors. Overall, the system is perceived as convenient, requiring minimal knowledge to operate effectively and offering attributes that facilitate user control.

Table 5

Participants' mean ratings of barcode system reliability.

RELIABILITY	N	Mean	Std. Deviation	Rank	Interpretation
1. The system operates as intended despite the presence of the hardware.	80	3.40	.54191	3	Highly Reliable
2. The system maintains the integrity of data related to tracking borrowed tools.	80	3.45	.52531	2	Highly Reliable
3. The system maintains data accuracy even during high-volume or busy periods of tool and inventory tracking.	80	3.32	.67082	4	Highly Reliable
4. The system can recover the data directly affected, in the event of an interruption or a failure.	80	3.27	.61572	5	Highly Reliable
5. The system is operational and accessible when required for use.	80	3.46	.50174	1	Highly Reliable
General Weighted Mean	80	3.38	.47754		Highly Reliable
Valid N (list wise)	80				

The data in Table 5 indicates that the weighted average mean of participants' evaluations on the system's reliability is 3.28 which suggests a strong agreement among the participants regarding the reliability of the system. The statement with the highest mean score of 3.45 indicates that participants perceive the system as operational and accessible when needed. Followed by the statement about the system maintaining the integrity of data related to tracking borrowed tools received the second-highest mean score of 3.45.

Participants strongly agree on the reliability of the barcode system used for monitoring and inventory management of tools in the AMT Laboratory. The weighted average mean of participants' evaluations on the system's reliability is 3.28, with a standard deviation of 0.47754. This suggests a strong agreement among the participants regarding the reliability of

the system. Additionally, participants agreed that the system operates as intended despite the presence of hardware, with a weighted mean of 3.40. However, the mean scores for maintaining data accuracy during high- volume or busy periods of tool and inventory tracking, and for data recovery in the event of interruption or failure, are slightly lower with weighted means of 3.32 and 3.27, respectively. Several factors explain the slightly lower ratings. During high-volume periods, the barcode system could experience delays or performance issues, affecting data accuracy. The system might not be fully optimized for scalability, and data recovery features could lack efficiency, raising concerns about data loss.

In summary, the data indicates that participants strongly agree on the reliability of the barcode system in the AMT Laboratory. They believe the system is operational and accessible when needed, maintains data integrity, operates effectively despite hardware challenges, and demonstrates the ability to maintain data accuracy during busy periods and recover data in case of interruptions or failures. Overall, the system is considered highly reliable for monitoring and inventory management tasks in the laboratory.

Table 6

Participants' mean ratings of barcode system efficiency.

EFFICIENCY	N	Mean	Std. Deviation	Rank	Interpretation
1. The system streamlines the process of checking in and checking out tools and inventory items.	80	3.45	.54888	3	Highly Efficient
2. The system aligns with the specified requirements regarding utilization of resources such as barcode scanners, computer or laptop etc.	80	3.35	.55347	5	Highly Efficient
3. The system provides large scale capacity of availability and quantity of tools and inventory.	80	3.40	.56479	4	Highly Efficient
4. The system allows quick and easy monitoring of numbers of available tools and number of borrowers.	80	3.55	.50063	2	Highly Efficient
5. The system allows for quick and easy inquiry of the unreturned tools.	80	3.56	.49921	1	Highly Efficient
General Weighted Mean	80	3.46	.44505		Highly Efficient
Valid N (list wise)	80				

The data in Table 6 implies that the weighted average mean of participants' evaluations on the system's efficiency is 3.46, this suggests a strong agreement among the participants regarding the high efficiency of the system in effectively monitoring and managing tools.

Participants highly perceive the efficiency of the barcode system used for monitoring and inventory management of tools in the AMT Laboratory. The weighted average mean of participants' evaluations on the system's efficiency is 3.46, with a standard deviation of 0.44505. This suggests a strong agreement among the participants regarding the high efficiency of the system in effectively monitoring and managing tools. The statement with the highest mean score of 3.56 indicates that the system allows for quick and easy inquiry of unreturned tools. Followed by the statements regarding quick and easy monitoring of the

numbers of available tools and borrowers, as well as streamlining the process of checking in and checking out tools and inventory items, received high mean scores of 3.55 and 3.45, respectively, ranking second and third. On the other hand, the statements regarding the system's large-scale capacity of availability and quantity of tools and its alignment with specified resource utilization requirements received lower mean scores of 3.50 and 3.40, respectively, ranking fourth and fifth. The lower mean scores were due to its limitations in managing very large inventories and meeting complex resource planning needs. Users have found the system slower or lacking advanced features required for precise inventory control, leading to slightly lower evaluations in these areas.

In summary, the data implies that participants highly perceive the barcode system as efficient in the AMT Laboratory. The system is seen to be contributing significantly to effective tool monitoring and inventory management, offering quick and easy inquiry of unreturned tools, streamlined check-in and check-out processes, and convenient monitoring of tool availability and borrower numbers. Although the system's large-scale capacity and alignment with specified resource utilization requirements received slightly lower mean scores, participants still acknowledged the system's overall efficiency in supporting monitoring and inventory management tasks.

Table 7

Participants' mean ratings of barcode system compatibility.

COMPATIBILITY	N	Mean	Std. Deviation	Rank	Interpretation
1. The system is compatible with a different brands of barcode scanners available in the market.	80	3.26	.58987	5	Highly Compatible
2. The system effectively handles different types of tools and equipment in AMT inventory.	80	3.46	.50174	1	Highly Compatible
3. The system's barcode scanning feature works well with various sizes and shapes of barcode labels.	80	3.37	.66323	3	Highly Compatible
4. The system is adaptable software that works well on window and MacOS devices.	80	3.30	.66371	4	Highly Compatible
5. The system contains a number of system features that work well for an immediate inventory management solution.	80	3.45	.50063	2	Highly Compatible
General Weighted Mean	80	3.37	.50023		Highly Compatible
Valid N (listwise)	80				

The data in Table 7 implies that the weighted average mean of 3.37, indicates that participants view the system as highly compatible. Among the items evaluated, item 2 received the highest mean score of 3.46. The second-highest mean score of 3.45 was obtained for item 5. On the other hand, the lowest mean score of 3.26 was obtained for item 1, were due to limited interoperability, where the system was optimized for specific scanner models but did not perform as reliably with others which will lead to inconsistent scanning performance, device connection issues, or the need for additional setup steps, affecting user experience, which

refers to the system's compatibility with different brands of barcode scanners available in the market.

Overall, the data suggests that the monitoring and inventory management system using the barcode system in the AMT laboratory tools is compatible for the organization's needs. However, there is room for improvement in terms of compatibility, particularly in ensuring compatibility with different brands of barcode scanners. The system's effectiveness in handling various types of tools and its well-functioning features are seen as significant advantages.

Table 8

Participants' mean ratings of barcode system security.

SECURITY	N	Mean	Std. Deviation	Rank	Interpretation
1. The system information is confidential and only accessible to authorized personnel or AMT tool keeper.	80	3.00	1.00631	1	Highly Secure
2. The system enables security purposes and features in storing information.	80	2.95	1.00505	4	Secure
3. The system ensures that all the information in the database is protected.	80	3.00	1.00631	2	Highly secure
4. The system guarantees the secure and efficient control of inventories for optimal management.	80	2.96	1.02431	3	Secure
5. The system security is continually monitored and maintained to prevent security breaches during operation.	80	2.85	.99492	5	Secure
General Weighted Mean	80	2.95	.90189		Secure
Valid N (listwise)	80				

The data in Table 8 shows that the weighted average mean of participants' evaluations for the system's security is 2.95, which indicates that participants generally agree with the security features of the system, albeit with some room for improvement. The statements regarding the system's ability to maintain confidentiality and protect information in the database received the highest mean rank of 3.00. On the other hand, the statement regarding the continual monitoring and maintenance of system security to prevent security breaches during operation received the lowest mean rank of 2.85, this is due to users perceiving a lack of visible or robust security measures, such as real-time threat detection, regular system updates, or strong data protection protocols.

Overall, the data highlights the importance of maintaining and enhancing the security features of the system to ensure the protection and confidentiality of sensitive information within the monitoring and inventory management process.

Table 9 presents data on the different aspects of the barcode system's usage quality features, and it indicates that functionality received the highest general weighted mean of 3.48. This high score imply that the barcode system's functionality is well-regarded and deemed favorable by the users when it comes to accurately recording tool information (including

descriptions and quantities), performing back-ups, importing and exporting data, ensuring consistent functionality, and enabling the generation of barcodes.

Table 9

Summary of participants' ratings on the barcode system.

	Gen. Weighted Mean	Std. Deviation	Rank	Interpretation
Functionality	3.48	.4875	1	Highly Functional
Usability	3.42	.47317	3	Highly Usable
Reliability	3.38	.47754	4	Highly Reliable
Efficiency	3.46	.44505	2	Highly Efficient
Compatibility	3.37	.50023	5	Highly Compatible
Security	2.95	.90189	6	Secure

Table 9 also shows that it is evident that the security feature received the lowest general weighted mean of 2.95, these results suggest that the user participants were not entirely convinced about the security measures offered by the system. The data presented in table 14 highlights the need for improvement in the system's capability to create a secure and safe environment for monitoring and inventory management. Users expect the system to ensure that sensitive information is accessible only to authorized personnel, and currently, there seems to be room for enhancing these security features. Despite having both the highest and lowest ranks, the features in the tables received high grades overall. This indicates that even if the security feature is not the strongest, the barcode system is still capable of performing its function and is feasible for development and implementation at PhilSCA. The system will undoubtedly assist all user participants in their tool transactions in the AMT laboratory.

Table 10 presents the weighted average mean for the overall assessment is 3.49, indicating a strong agreement among participants that the barcode system is highly accurate and provides the desired monitoring and inventory management benefits. Among the five items, item number two received the highest mean score of 3.56. Item four and item five ranked as the second and third highest mean scores of 3.52 and 3.5, respectively. Moreover, participants perceive the system to be advantageous in terms of providing accurate borrower information and reducing errors in data recording through the scanning process. The mean scores for these aspects are 3.48 and 3.37.

Table 10

Participants' mean ratings of barcode system accuracy benefits.

ACCURACY	N	Mean	Std. Deviation	Rank	Interpretation
1. The system provides accurate information about the borrower of the tools within the inventory system.	80	3.48	.50300	4	Highly accurate
2. The system accurately identifies each tool based on its unique barcode.	80	3.56	.49921	1	Highly accurate
3. The system minimizes errors in recording tool data during the scanning process.	80	3.37	.60326	5	Highly accurate
4. The system accurately reflects the status of the tools (e.g., borrowed, available, returned)	80	3.52	.52711	2	Highly accurate
5. The system provides accurate date of transactions for record keeping.	80	3.50	.55118	3	Highly accurate
General Weighted Mean	80	3.49	.45884		Highly accurate
Valid N (listwise)	80				

Overall, the results suggest that the utilization of a barcode system for monitoring and inventory management in the AMT laboratory tools is highly accurate and highly recognized by the participants. They perceive it as an effective and beneficial tool for managing tool transactions in our AMT laboratory tool room. Implementing this system could potentially enhance productivity, efficiency, and accuracy in monitoring and managing inventory, benefiting students, faculty, and tool keepers alike.

Table 11

Participants' mean ratings of barcode system technology benefits.

TECHNOLOGY	N	Mean	Std. Deviation	Rank	Interpretation
1. The system utilizes advance technology for efficient scanning and data capture.	80	3.40	.51803	5	Highly technological
2. The system offers a responsive and intuitive user interface for streamline operations.	80	3.46	.52636	3	Highly technological
3. The system can be access without the need for an internet connection.	80	3.51	.52756	2	Highly technological
4. The system assists students and faculty in practicing advance tool transactions in the aviation industry.	80	3.52	.52711	1	Highly technological
5. The system offers advance learning opportunities for students and faculty in tool transactions.	80	3.45	.52531	4	Highly technological
General Weighted Mean	80	3.47	.43411		Highly technological
Valid N (listwise)	80				

Table 11 displays the weighted average mean for participants' assessment of the system's technological benefits is 3.47, indicating a high agreement that the system is advantageous in technological advancements. Among the five items, item four obtained the highest mean score of 3.52, ranking first. The item one and five both obtained lower mean

scores, with 3.40 and 3.45, ranking fifth and fourth. The item two and three both obtained a high mean scores of 3.46 and 3.51, ranking third and second, respectively.

The findings indicate that implementing a barcode system for monitoring and inventory management in the AMT laboratory tools is highly beneficial in technological advancement. The system's technology has the potential to significantly enhance the effectiveness and efficiency of monitoring and inventory management processes while also promoting advanced learning and growth opportunities for both students and faculty.

Table 12

Participants' mean ratings of barcode system cost-effectiveness benefits.

COST-EFFECTIVESS	N	Mean	Std. Deviation	Rank	Interpretation
1. The system has reduced costs associated with manual tracking and recording of tool inventory.	80	3.35	.55347	4	Highly cost-effective
2. It improves overall efficiency, leading to cost savings in tool handling and tracking.	80	3.37	.53663	3	Highly cost-effective
3. It reduces the additional labor or resources for inventory management.	80	3.33	.54988	5	Highly cost-effective
4. It helps prevent losses or theft of tools, resulting in financial savings.	80	3.37	.55972	1	Highly cost-effective
5. It reduces the use of papers and pens resulting in cost savings.	80	3.37	.55972	2	Highly cost-effective
General Weighted Mean	80	3.36	.46887		Highly cost-effective
Valid N (listwise)	80				

Table 12 presents the evaluation average mean rating of 3.36, indicating that most participants strongly agree that the system is highly cost-effective. The findings indicate a strong agreement among participants regarding the system's advantages, particularly items two, four, and five. These benefits encompass the monitoring of tool transactions, which aids in preventing losses or theft, reduces reliance on paper and pens, and enhances overall efficiency, thereby resulting in cost savings. These items obtained a mean rating of 3.37, securing the first, second, and third positions among the five items. Furthermore, two additional cost-effective benefits, namely reduced expenses associated with manual tracking and decreased demand for additional labor or resources, also received high mean ratings ranging from 3.35 to 3.33. Furthermore, two additional cost-effective benefits, namely reduced expenses associated with manual tracking and decreased demand for additional labor or resources, also received high mean ratings ranging from 3.35 to 3.33. This outcome indicates that participants strongly agreed with these specific benefits as well.

The participants' positive evaluation of the barcode system for monitoring and inventory management in the AMT laboratory tools demonstrates its effectiveness in achieving cost savings and fulfilling the needs of the AMT laboratory tool room. This implementation has

enabled the institution to allocate resources efficiently and still provide advanced and cost-friendly software systems, contributing to the development of skilled graduates.

Table 13

Summary of participants' ratings on barcode system benefits.

	Gen.Weighted Mean	Std. Deviation	Rank	Interpretation
Accuracy	3.49	.45884	1	Highly Accurate
Technology	3.47	.43411	2	Highly Technological
Cost-effectiveness	3.36	.46887	3	Highly Cost- effective

Table 13 presents the benefits of the proposed barcode system in the AMT laboratory. The data reveals that the accuracy obtained the highest general weighted mean of 3.49, with a standard deviation of 0.45884. This indicates that the system's accuracy benefits are highly regarded. The high general weighted mean of 3.49 suggests that the system performs exceptionally well in accurately reading and processing barcodes. In contrast, among the three benefits, the cost-effectiveness received the lowest mean score of 3.36, with a standard deviation of 0.46887, this is due to the institution's government-run nature. Although the barcode system may offer long-term savings, the initial setup costs—including purchasing equipment and training, which have made it seem more expensive compared to the existing manual system. Despite this lower score, it is still interpreted as highly cost-effective. It is important to note that, according to the data presented in the table, accuracy ranked the highest among the system benefits, while cost-effectiveness ranked the lowest. However, it is evident from the overall interpretation that all the benefits offered by the barcode system successfully met the needs and expectations of the user participants.

Based on the provided information, the barcode system appears to be feasible for implementation in the AMT laboratory. The fact that the barcode system's features and benefits received high ratings and met the needs and expectations of the user participants suggests that it is well-suited for practical use. Moreover, the data emphasizes that the barcode system meets the ISO 25010 standard for software effectiveness.

Table 14

Interpretation key informant interview: Barcode system

Questions	Responses
Name (optional): Designation in school: Course and Year Level (if student)	• (1) Student • (2) Student • (3) Faculty • (4) Instructor • (5) Tool keeper
What challenges did you experience in the manual method of borrowing, monitoring, and inventory	• (1) Takes time • (2) Time consuming • (3) Time consuming • (4) Consumes a lot of time
process in our tool room?	• (5) Slow in tool transaction
What are your expectations in the barcode system for tool monitoring and inventory management?	• (1) Convenient and accurate • (2) Time efficient and hassle free • (3) More efficient • (4) Hassle free and more convenient • (5) More convenient and less prone to errors
What are the advantages can you get from an improved monitoring system?	• (1) Exposed on what happening on the field and be responsible on the tool • (2) More productive, allocate more time • (3) Save time and effort, can instill responsible borrowers • (4) Time efficient and save more task to do • (5) Useful and helpful to easily record tools
How important is the time efficiency when it comes to borrowing tools and conducting inventory?	• (1) Cost lesser time, • (2) Important, transact tools faster • (3) Important, task for the students is only limited • (4) Very important, limited time or specific schedule • (5) Very important, do more task
How do you think can we incorporate the barcode system into our existing workflow for monitoring tools and managing inventory?	• (1) Change current tool monitoring • (2) Current workflow need budget and capacity to fully implement • (3) Improve current workflow • (4) Enhance current process • (5) Improve tool transaction

The researcher's analysis of the interviews showed that most users are open to using the barcode system for tool monitoring and inventory management. The participants believe that the barcode system has benefits, such as making tool borrowing easier, time efficient and helps students and teaching staff to develop a sense of responsibility.

However, some potential challenges and issues may arise during the implementation of the barcode system. One interviewee mentioned that while development could be feasible,

the actual implementation could be difficult due to budget constraints, because the institution, being government-run, must undergo strict bidding processes for budget approvals, causing delays and limiting flexibility even when development is ready. Though this issue may be an internal matter within the institution, the concept of streamlining the tool transaction process in the AMT laboratory tool room through barcode monitoring and inventory system has proven effective as a substitute to the current tool monitoring and inventory management process. Furthermore, during the interviews, most participants agreed that this system benefits them. Not only does it reduce waiting times and expedite the process, but it also contributes to their productivity in laboratory activities.

The participants agreed on the barcode system's capabilities to enhance productivity, foster a sense of responsibility, and provide advanced technological experience. They firmly believe that embracing advanced technical practices is essential to maintaining best aviation practices. Furthermore, participants acknowledge that utilizing advanced technological tools enhances the institutions' laboratories and contributes to developing highly skilled graduates.

Table 15

Key informant interview results on barcode system implementation in PhilSCA

ADDITIONAL KII QUESTIONS AND RESPONSE FOR TEACHING STAFF	
Questions	Responses
Do you think it is feasible to implement a barcode system in the AMT laboratory?	• (3) Feasible to implement • (4) Yes, it is feasible
If yes. What do you think the requirements are and how can it be implemented? If no, why do you think it is not feasible to implement?	• (3) It would require equipment such as laptop, etc., it also require a system feature that is well planned and equipped, a strategic plan, also it need budget • (4) preparation such as materials, orientation to students, software that meets the standard
What are the possible problems or challenges may encounter?	• (3) budget approval, concrete plan • (4) a fund and time of implementation

Interpretation of data and thematic analysis were used on the data gathered from interviews. Table 15 shows the results of the interview with the teaching staff of AMT department of PhilSCA. As revealed, the barcode system brings many advantages in streamlining various processes within the institution. The barcode system has six (6) key features: functionality, usability, reliability, efficiency, compatibility, and security- which contribute to its effectiveness and flexibility. These features make the barcode system an essential tool for the AMT laboratory at PHILSCA, helping the institution achieve efficient inventory management and tool monitoring. Its adaptability to different user needs makes it a comprehensive solution for modernizing and optimizing laboratory operations.

According to the participant feedback, the feasibility of implementing the barcode system is contingent upon meeting certain requirements, including hardware materials, software components, well-defined plans, and the allocation of a suitable budget. This indicates that successful implementation is achievable, provided that the software aligns with the ISO 25010 standard for software development and includes necessary training or orientation sessions for students, teaching staff, and non-teaching personnel to foster familiarity and competence with the barcode system.

By adopting this technology, PHILSCA can explore additional ways to harness's the barcode system's capabilities, improving overall performance and remaining at the forefront of educational technological advancements. Although interviewees mentioned potential internal challenges during implementation like budget constraints as a government funded institution, potential internal challenges like budget constraints during implementation, the survey results and interviews consistently underscored the system's highly rated and beneficial features for the users, reinforcing its potential positive impact on the institution.

Table 16

T-test result on the significant difference of participants on the benefits of barcode system

BENIFITS	Designation	N	Mean	Std. Deviation	t-value	p-value	Interpretation
ACCURACY	Student	70	3.4971	.46780	.366	.715	Not Significant
	Teaching & Non-teaching staff (Tool Keeper)	10	3.4400	.40879			
TECHNOLOGY	Student	70	3.4714	.43743	.077	.939	Not Significant
	Teaching & Non-teaching staff (Tool Keeper)	10	3.4600	.43256			
COST- EFFECTIVESS	Student	70	3.3286	.47431	-1.734	.087	Not Significant
	Teaching & Non-teaching staff (Tool Keeper)	10	3.6000	.36515			

An independent sample t-test was conducted to test the significance between the students, and teaching and non-teaching participants on the benefits of Barcode System for AMT laboratory tools.

The results show that there were no significant differences between the students, and teaching and non-teaching participants on the proposed barcode system in terms of its accuracy (t=0.366, p=.715), technology advancement (t=0.077, p=.939), and cost-effectiveness (t=-1.734, p=.087). Since the p-values are greater than the alpha at .05 level of significance, we failed to reject the null hypothesis. This implies that the students and teaching and non-teaching staff have similar assessment regarding the barcoding system can be beneficial for AMT laboratory tools.

Table 17

Barcode system: System recommendation by ranking

Item	N	Rank
Functionality	34	1
Usability	32	6
Reliability	25	7
Efficiency	33	9
Compatibility	25	8
Security	22	4
Accuracy	22	2
Technology	27	5
Cost-effective	20	3

Table 18

Barcode system tallied recommendation ranking report

ITEM	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7	Rank 8	Rank 9	
Functionality	34	11	7	2	7	5	10	3	1	80
Usability	2	4	16	3	5	32	8	3	7	80
Reliability	14	4	5	8	2	11	25	5	6	80
Efficiency	1	7	11	11	2	6	2	7	33	80
Compatibility	11	3	3	9	1	3	7	25	18	80
Security	5	20	1	22	20	1	8	2	1	80
Accuracy	1	22	15	10	5	9	16	1	1	80
Technology	10	8	2	1	27	4	2	25	1	80
Cost-effective	2	1	20	14	11	9	2	9	12	80
	80	80	80	80	80	80	80	80	80	N

Based on the study findings, the researcher recommends prioritizing the functionality and accuracy aspect of the barcode system, as it received the first and second highest rank score in the survey questionnaire. This means focusing on enhancing its performance, efficiency, and accuracy to cater to various applications effectively.

Secondly, the researcher suggests allocating resources and efforts to address the security aspect of the barcode system, as it received the third and fourth highest rank in the result of survey questionnaires. Strengthening security measures will help prevent unauthorized access, data breaches, and potential vulnerabilities. Furthermore, it is essential to work towards optimizing the cost-effectiveness of implementing and maintaining the barcode system in the school, ensuring an efficient solution that meets its diverse needs and requirements.

Overall, the study findings indicate that the proposed barcode system holds significant promise for enhancing tool room management in the AMT laboratory at PhilSCA. The researcher suggests implementing the system at PhilSCA and conducting seminars for students, teaching, and non-teaching staff to ensure effective utilization. This approach will enhance documentation quality and foster greater awareness of their tasks. Emphasizing policies, rules, and standard operating procedures during the seminars will guarantee the system's efficient and effective use.

Conclusion

The study examined the perspectives of participants from various roles within the AMT laboratory, emphasizing the diverse insights on the functionality, usability, and benefits of the barcode system. While the system offers significant advantages in functionality and accuracy, there's a crucial need to address security features to ensure successful implementation and optimize cost-effectiveness. Despite potential budget constraints, the implementation of the barcode system at PhilSCA's AMT laboratory is considered feasible, contingent upon meeting user requirements. Analysis revealed uniform positive perceptions of the system's benefits among students, teaching, and non-teaching participants. Recommendations include prioritizing functionality and accuracy enhancements, strengthening security measures, and optimizing cost-effectiveness. Proceeding with implementation and conducting seminars for proficient usage are advised to maximize the system's potential benefits.

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