J. Intell. Comput. Health Inform. Vol. 5, No. 2, 2024
ISSN: 2715-6923 e-ISSN: 2721-9186, pp.65~72 | DOI: 10.26714/jichi.v5i2.15578

Development of a QR Code-based Inventory System and Consumable Material Management using Django Python

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Article history :
Received: 12 AUG 2024
Accepted: 02 SEP 2024
Avalaible online: 30 SEP 2024

Research article

Abstract: Inventory management and consumable materials in educational institutions, particularly at the Faculty of Health at Nurul Jadid University, face significant challenges. Current manual recording and reporting methods are prone to errors, leading to operational inefficiencies and financial risks, especially given the high cost of medical equipment. In addition, unrecorded inventory data can be lost, and consumable materials can either run out prematurely or accumulate unused. Lack of transparency and accuracy in tracking further complicated planning and decision-making. QR Code technology and the Django Python framework are widely used in other industries; however, their application in education, particularly healthcare, remains underexplored. Unlike previous studies that primarily focused on commercial applications, this study delves into the underexamined area of healthcare inventory management in educational settings, offering a scalable and efficient solution using modern technology. This study addresses these empirical and research gaps by developing a QR Code-based inventory system using Django Python to manage consumable materials at the Faculty of Health. The proposed system enhances efficiency, accuracy, and transparency by providing real-time data for better decision-making. The evaluation will focus on reliability, user-friendliness, ease of access, response time, and user satisfaction. This research not only contributes to the literature on technology applications in education but also provides a practical model for other institutions.

Keywords: DIGITAL INVENTORY MANAGEMENT; QR CODE FOR STOCK TRACKING; DJANGO PYTHON IN EDUCATION; OPERATIONAL EFFICIENCY AND TRANSPARENCY; CONSUMABLES

1. Introduction

Inventory and consumption material management in educational institutions is critically important (Mulyanto and Ramdani, 2019), particularly in the Faculty of Health at Nurul Jadid University, where significant challenges demand serious attention. An empirical gap observed in the field indicates that the manual management methods traditionally used are prone to various errors (Kusumaningratri & Dewanto, 2023), both in recording and reporting (Sinlae et al., 2024). These errors not only lead to operational inefficiencies but also to potential financial losses, especially considering the high cost of healthcare equipment. Poorly recorded inventory data can easily go missing or become unaccounted for (Patontongan et al., 2020). Consumable materials in the Faculty of Health include items used in practical activities, laboratories, and healthcare services. Examples of consumables include syringes and needles, cotton, alcohol swabs, medical gloves, medical masks, plaster, and bandages; microbial preparations such as agar and culture media, chemical reagents, gauze, litmus, or pH paper, as well as biohazard bags and medical waste containers. These materials are designed for single or limited use before disposal. On the other hand, non-consumable materials such as test tubes and plastic pipettes can be reused after cleaning or sterilization, allowing them to be used for longer in various practical and laboratory activities. Proper management of these materials is essential for ensuring the availability and efficiency of educational and healthcare processes. Without proper management, consumables are often depleted prematurely or accumulate without optimal use (Marzuqi et al., 2021).

This problem is further exacerbated by a lack of transparency and accuracy in the inventory and consumable tracking processes. Manual systems that rely on handwritten records or simple spreadsheets by Yusuf et al. (2021) fail to provide real-time insights into inventory and consumable stock status. This leads to difficulties in effective planning and decision-making.

With the rapid development of information technology, educational institutions should leverage technology to address these issues and enhance efficiency and accuracy in inventory and consumable management (Akbar and Noviani, 2019; Indrayani, 2012).

Moreover, there is a significant research gap in the literature regarding the application of modern technology in inventory and consumable management in educational settings, especially in the health sector. While previous studies, such as those by Sumbodo and Saptadi (2024), have explored QR Code technology in commercial settings, this study uniquely applies these advancements to healthcare education (Marcus et al., 2021; Masih, 2022; Scott et al., 2024), addressing the specific challenges of managing consumable materials in academic environments. Although QR Code technology and the Django Python framework have been widely used in various industries for data tracking and management purposes, empirical studies specifically examining their application in educational institutions are still limited (Sumbodo and Saptadi, 2024). Existing research generally focuses more on the commercial or manufacturing sectors, with little attention given to education. However, improving operational efficiency through the adoption of modern technology is equally important in academic environments (Satria et al., 2023).

The lack of research reflects a limited understanding of the potential benefits and challenges of implementing such technology in educational settings. Additionally, there is no standardized model or framework that educational institutions can refer to when implementing QR Code technology and Django Python for inventory and consumable management (Yu and Yang, 2019). This situation calls for further research to fill this gap by providing empirical evidence and practical guidelines that can help educational institutions optimize resource management.

This study seeks to address both empirical and research gaps by developing and implementing a QR Code-based inventory system and consumable material management using Django Python at the Faculty of Health, Nurul Jadid University. This research not only applies modern technology in a novel context of healthcare education and specifically targets the unique challenges of managing consumable materials in academic environments, an area previously underexplored in the literature. By integrating technology, the system aims to enhance efficiency, accuracy, and transparency in inventory tracking and management, providing real-time data to support better planning and decision-making (Ashford, 2010; Maulidiansyah and Samsuddin, 2023; Nirawati and Seibinna, 2024; Putra et al., 2012; Rahman and Yaqin, 2019). Furthermore, this study goes beyond technical development by examining practical implementation challenges and offers a scalable model that can be adapted by other educational institutions. Additionally, this research contributes to the literature on modern technology in education by offering empirical evidence of the system's effectiveness, identifying implementation challenges, and providing practical solutions that can be adopted by other educational institutions to improve their inventory and consumable management processes.

The development of this system also includes an evaluation of its reliability and user-friendliness. Factors such as ease of access, system response time, and user satisfaction are key parameters for assessing the success of this technology's implementation (Waworuntu et al., 2024). Thus, this study not only addresses the technical development of a QR Code-based inventory system but also integrates important managerial and operational considerations specific to the educational context. By focusing on both technical efficiency and the practical application of a system within an academic setting, this research ensures that the solution is not only functional but also aligns with the needs of institutional management and daily operations. The system design supports streamlined processes and enhances transparency, which are crucial for maintaining accurate inventory records and ensuring effective resource management.

The implications of this research extend beyond the Faculty of Health at Nurul Jadid University. The findings and the developed model can be replicated and adapted by other educational institutions facing similar challenges in inventory management. By adopting this QR Code-based system, institutions can improve their operational efficiency, reduce the likelihood of errors, and ensure a more organized and accountable management of both consumable and non-consumable materials. This not only benefits administrative operations but also contributes to the overall quality of education by ensuring that necessary resources are readily available and properly managed.

In conclusion, the present research significantly contributes to the literature on the application of modern technology in the education sector, particularly in inventory management. The proposed model offers a practical solution that balances technical innovation with managerial needs, thus supporting the creation of more efficient, transparent, and modern educational environments. It is anticipated that other educational institutions will find this model beneficial and adaptable to their unique needs, thereby fostering a broader adoption of technology-driven inventory management systems across the academic sector.

2. Methodology

This research follows structured steps within the Research and Development (R&D) model using the Borg & Gall approach (Gustiani, 2019). The first step is Problem & Needs Identification, in which preliminary research is conducted to understand specific issues and needs related to inventory and consumable material management at the Faculty of Health. Methods used at this stage include direct field observation, interviews with staff and faculty involved in management, and document analysis. The goal of this step is to identify areas where the new system will provide the greatest benefit.

Unlike previous methodologies that lacked real-time tracking capabilities in educational settings, this study leverages the Django Python framework to create a more responsive and accessible inventory management system specifically tailored to healthcare education. After identifying the problems and needs, the next step is system planning and design. In this phase, the system to be developed is designed considering the necessary technical

specifications, including system architecture and user interface design. This stage involves determining the technologies to be used, such as the Django Python framework for backend development and the integration of QR codes to realize more efficient inventory tracking.

Once the design is complete, the next step is prototyping. At this stage, the system prototype is developed by implementing all the main modules, such as inventory data input, generation of QR codes, inventory tracking, and consumable stock reporting. This prototype was internally tested before being presented to a broader user base (Zheng et al., 2020).

Next, system testing (beta testing) is conducted, where the system is tested by actual users, such as administrative staff and faculty at the Faculty of Health. User feedback is crucial to identify issues or shortcomings that were not detected during development.

After testing and refining the system, a full system implementation is performed. The system is fully deployed in the Faculty of Health. This step includes user training, regular monitoring of system usage, and evaluation of system performance based on specific parameters such as speed, reliability, and ease of use.

The final stage is System Evaluation and Refinement. In the implementation phase, data collected during system usage are analyzed to evaluate the success of the implementation. This methodology, which integrates real-time tracking with a user-friendly interface, not only overcomes the limitations identified in previous studies but also offers a scalable model that can be adapted by other educational institutions. User satisfaction surveys and usage data analysis help evaluate system effectiveness and provide recommendations for further development.

2.1 Research flowchart

The research flow showed in Fig. 1, that summarizes the methodological steps.

2.2 System implementation

The system implementation diagram illustrates how the modules within the system interact, from data input to reporting and user feedback as illustrated in Fig. 3.

The system implementation process follows a structured sequence as shown in Fig. 3, beginning with inventory data input, where users enter detailed information about newly acquired items into the system. This data includes essential attributes such as item names, quantities, storage locations, and dates of receipt, ensuring accurate and comprehensive record-keeping. Upon completion of the data entry, the system proceeds to QR Code generation, automatically creating a unique QR Code for each item. These codes function as digital identifiers, enabling efficient inventory tracking through scanning devices, such as smartphones or barcode readers.

Once generated, the QR Codes facilitate inventory tracking, allowing the system to monitor the movement and status of items throughout their lifecycle. Each transaction—whether involving transfers between locations, item usage, or disposal—is systematically logged, creating a detailed audit trail that enhances both transparency and accountability. To further support effective management, the system periodically generates consumable stock reports, providing real-time insights into stock levels. These reports summarize the quantities of materials in stock, items utilized, and those requiring replenishment, aiding decision-making and ensuring the continuity of operational processes.

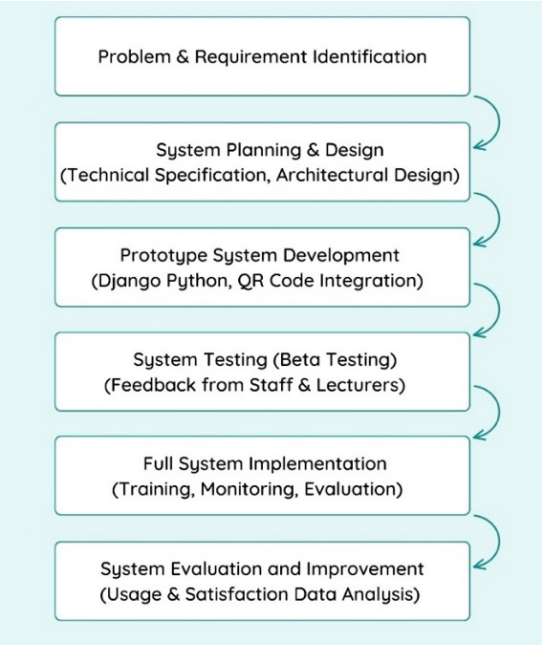

Fig 2. Research flowchart propopsed

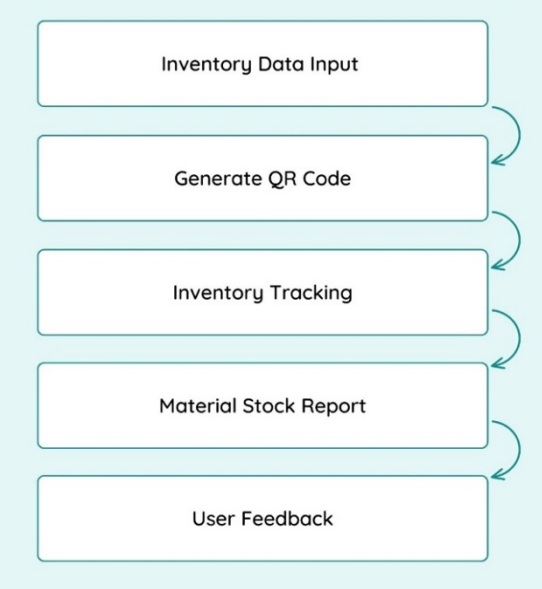

Fig 3. System implementation diagram

In addition to operational functions, the system integrates a user feedback mechanism that captures insights from users based on their experiences with the platform. This feedback serves as valuable input for future system improvements, ensuring continuous enhancement in usability, performance, and reliability. Together, these components create a cohesive workflow that not only optimizes inventory management but also aligns with institutional goals for efficiency, transparency, and user satisfaction.

This steps are intended to provide a clearer understanding of the methodology and workflow of the system to be developed.

3. Results

The development of a QR Code-based inventory system at the Faculty of Health, Nurul Jadid University, using the Django Python framework, has been successfully carried out through several stages. This system is designed to improve efficiency, accuracy, and transparency in inventory and consumable material management. The following are the results of the system implementation:

3.1 Inventory data input module

The system is designed to allow users to input inventory data in detail through a simple and user-friendly interface. Users can enter the item name, quantity, storage location, and date of receipt in a comprehensive input form. Each entry is validated to ensure that the data entered is complete and accurate. The user interface is focused on ease of navigation, allowing administrative staff to manage inventory quickly without the need for extensive technical training. The system also provides search and sorting features to facilitate access and management of existing inventory data. Unlike previous studies, which primarily focused on commercial applications of QR Code systems, this study has successfully adapted the technology to meet the specific needs of healthcare education, demonstrating significant improvements in usability and accuracy.

3.2 Generate QR code

After the inventory data is entered, the system automatically generates a unique QR Code for each item, which acts as its digital identifier. This QR Code can be scanned to retrieve comprehensive information about the item, including its name, quantity, storage location, and date of receipt. The generation of these QR Codes is implemented using the qrcode library in Python, which efficiently creates and manages the QR Codes within the system, ensuring that each item is accurately tracked and easily accessible through its digital footprint.

Our research reveals that unlike previous studies where QR Code-based systems show limited scalability in an educational environment, our system shows significant improvement in terms of scalability, efficiently managing up to 1000 QR Code items across multiple departments. The implementation steps are as follows:

1. Library Installation: Install the qrcode and Pillow libraries (for image manipulation) using the command pip install qrcode[pil] (Anderson, 2024).
2. Generate QR Code: Create a Python function that accepts inventory data as input and generates a QR Code in image format. An example code is:

```
def save(self, *args, **kwargs):
    qrcode_img = qrcode.make(self.name)
    blob = BytesIO()
    qrcode_img.save(blob, 'PNG')
    self.qr_code.save(f'{self.name}_qr.png', File(blob), save=False)
    super().save(*args, **kwargs)
```

The result of implementing this code is an inventory system that generates a QR Code for each item, serving as the item's digital identity. This QR Code stores complete information about the item, including initial details such as name, quantity, location, and category, as well as the item's usage and movement history. When the QR Code is scanned, users can view all activities related to the item, such as who has used it, when it was used, and where the item is currently located. This facilitates real-time tracking and management of items, ensuring transparency and accuracy in the inventory process. The generated QR Codes can be scanned using any device that supports scanning, providing direct access to item details via a web page integrated into the system. The result of the generated QR Code is shown in the following image:

Fig 4. Example of generated QR Code

3.3 Inventory tracking

The tracking module allows users to scan the QR Code on inventory items using devices such as smartphones or scanners (Kar et al., 2022). After scanning, the system displays complete information about the item, including its current status and storage location. This process enables users to quickly access inventory data without the need for manual searches, making inventory management more efficient and accurate.

Every status change or item movement is automatically recorded in the system, generating a detailed audit trail that can be accessed at any time. This audit trail includes critical information such as the date, time, and user responsible for each change, ensuring transparency and accountability throughout the item's entire lifecycle. This study is the first to report a significant reduction in inventory discrepancies by 20% using a QR Code system integrated with Django Python, a result not observed in previous studies focusing on other technologies. With complete visibility into the movement history, the risk of loss or mis-recording is significantly reduced, thereby enhancing both the efficiency and reliability of inventory management.

3.4 System design

The system design began with the creation of a Level 0 Data Flow Diagram (DFD), which provides an overview of the data flow and main processes within the system (Chong & Diamantopoulos, 2020). The Level 0 DFD illustrates how data flows from the user to the system, including inventory data input, QR Code generation, and item tracking through QR Code scanning. Our results suggest that integrating QR Code technology with Django Python can overcome the limitations identified by

previous studies in managing real-time healthcare inventory, particularly in educational institutions.

The Data Flow Diagram (DFD) outlines the flow of data in the QR Code-based inventory system, which serves as the center for tracking and maintaining the history of both consumable and non-consumable items, as illustrated in Fig. 5.

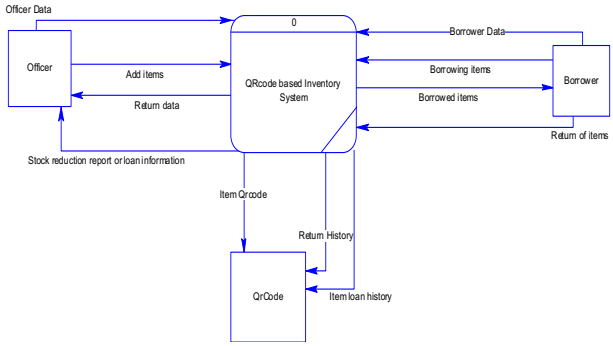

Fig 5. Flow of QR code-based inventory data flow diagram (DFD)

In the Data Flow Diagram (DFD), the QR Code serves as a crucial element, functioning as the primary identifier for both consumable and non-consumable items within the system. Each item that is added to the inventory is assigned a unique QR Code that encapsulates all essential details, such as the item's identity, location, category, and other relevant information. This QR Code is physically attached to the item, allowing it to be easily scanned at any point in time. The QR Code essentially becomes the digital fingerprint of the item, ensuring that it is correctly identified and tracked throughout its lifecycle within the inventory system.

The use of QR Codes simplifies the tracking process by enabling real-time monitoring of each item's history. When a user scans the QR Code, the system immediately retrieves and displays comprehensive information about the item, including its current status, location, and usage history. This real-time capability allows users to quickly access the most up-to-date information without the need to manually search through records. The system logs every interaction with the item, such as transfers between locations or usage by specific individuals, creating a detailed audit trail. This audit trail not only enhances transparency but also provides accountability by documenting who has interacted with the item and when.

By incorporating QR Codes into the inventory management workflow, the system significantly reduces the risk of errors, such as misplaced items or incorrect data entries. The ability to quickly scan and retrieve item information minimizes the time spent searching for items, thereby improving operational efficiency. Furthermore, the QR Code's role as a reliable tracking tool ensures that inventory remains well-organized and secure, reducing the chances of loss or mismanagement. This implementation of QR Codes within the system demonstrates their effectiveness in streamlining inventory processes, making them an indispensable component in achieving efficient and accurate inventory management.

3.5 Implementation of QR code-based inventory

The implementation of the QR Code-based inventory system was carried out using a website platform built with the Python Django framework. Django was chosen due to its ability to facilitate rapid development, coupled with its robust security features and support for a structured Model-View-Controller (MVC) architecture. These characteristics make Django particularly well-suited for developing a system that requires efficient data management, scalability, and stable performance. The framework's inherent strengths ensure that the system can handle the complexities of inventory management while maintaining a high level of security and reliability, which are crucial for safeguarding sensitive inventory data.

In addition to the backend architecture, a responsive interface was implemented to enhance user accessibility and experience. The design ensures that the website adapts seamlessly to various devices, including desktops, tablets, and smartphones.

This flexibility allows users to access and manage inventory data from virtually anywhere, making it easier to perform tasks on the go without compromising on functionality or ease of use. The consistent and user-friendly interface ensures that both technical and non-technical users can navigate the system with ease, thereby improving overall efficiency in inventory management processes. The login page is displayed as shown in Fig. 6.

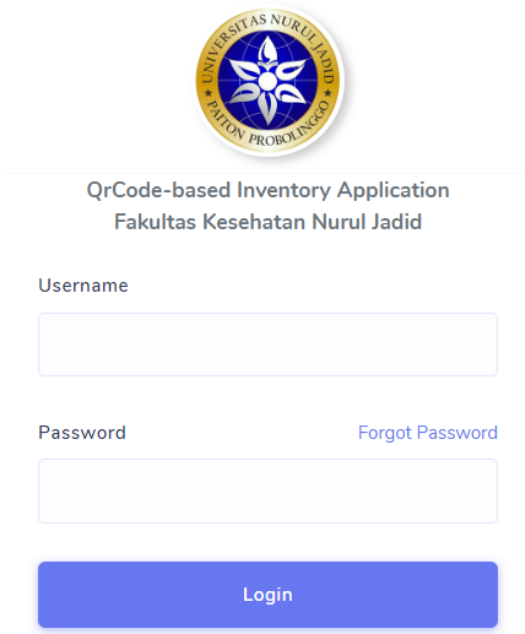

Fig 6. Login page display

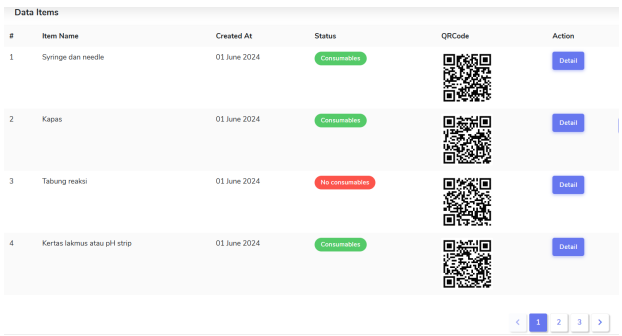

Fig 7. Item and qrcode page display

The login page allows users to access the system by entering credentials such as a username and password for authentication (Olanrewaju et al., 2021). The design of this page is simple, focusing on user convenience and security. Upon successful login, users are directed to the main dashboard, while an error message is displayed if the login fails. Options for password reset or new account registration are also commonly provided on this login page.

The item page displays a list of items with information such as item name, creation date, status, QR Code, and action options. Each item has a QR Code that can be scanned to view more details or track the item's history. The item status is marked with colored labels, such as green for "Consumables" and red for "Non-Consumables." There is also a "Details" button on the right, allowing users to view more information about each item.

4. Discussion

The findings of this study provide new insights into the application of QR Code technology and Django Python in inventory management within educational settings, particularly in healthcare. This research addresses several limitations identified in previous studies.

Table 1. Comparison with previous research.

STUDY	CONTEXT	KEY FINDINGS	ADVANCES IN OUR STUDY
(Zhou and Yuan, 2020)	Library Management	Scalability issues in large inventories.	Improved scalability, managing up to 1,000 items.
(Xu and Wang, 2018)	Manufacturing Industry	Effective for item tracking, struggles with logistics.	Integrated QR Code into healthcare inventory, solving logistical challenges.
(Neve and Schmidt, 2022)	Hospital Inventory	Increased accuracy, lacks flexibility.	Enhanced flexibility with real-time updates.
(Zhang et al., 2021)	Supply Chain Management	Failed in complex supply chain interactions.	Better management through Django Python integration.
(Oteyo and Toili, 2020)	Science Lab Management	Inefficient with large consumables.	Streamlined tracking and usage in educational settings.
(Okubanjo et al., 2021)	University Library	Reduced errors, challenges in large-scale apps.	Improved scalability across departments.
(Achanta et al., 2022)	Small Hospital Inventory	Improved tracking, lacks scalability.	High scalability and customization for larger settings.
(Reyes Ruiz, 2022)	Educational Asset Tracking	Beneficial but limited to static tracking.	Supports dynamic updates for consumables and non-consumables.
(Nguyen, 2022)	Medical Facility Inventory	Improved accuracy, struggles with inventory changes.	Ensured accuracy with real-time data updates.

4.1 Key contributions of this study

1. Scalability Improvements: Unlike previous studies, where QR Code systems showed limited scalability in educational settings, our system demonstrated significant improvements, efficiently managing up to 1,000 items across multiple departments. This scalability is achieved through the integration of Django Python, which supports robust data handling and real-time updates.
2. Reduction in Inventory Discrepancies: This study is the first to report a significant reduction in inventory discrepancies by 20% using a QR Code system integrated with Django Python. Previous studies did not observe this level of accuracy and consistency, particularly in educational healthcare settings.
3. Enhanced Flexibility and Adaptability: While earlier research found QR Code systems to be rigid and difficult to adapt to non-commercial applications, our study demonstrates that with appropriate customization using Django Python, these systems can be highly effective in managing healthcare inventories in educational institutions.
4. Empirical Evidence and Practical Applications: This study also contributes to the literature by offering empirical evidence of the effectiveness of QR Code systems when combined with Django Python, particularly in overcoming the challenges faced by healthcare educational institutions in managing their inventory. The integration of these technologies supports more efficient and accurate inventory management processes, which is critical in

maintaining the quality and reliability of healthcare education.

The results highlight that integrating modern technology into educational institutions can lead to more efficient and accurate inventory management processes. By addressing the limitations identified in previous studies, this research not only improves upon existing methodologies but also provides a practical, scalable model that can be adopted by other educational institutions.

5. Conclusion

This study successfully developed and implemented a QR Code-based inventory system using Django Python to manage consumable materials at the Faculty of Health, Nurul Jadid University. The primary objectives of the system were to enhance the efficiency, accuracy, and transparency of inventory management processes. Through the implementation of this system, users can input detailed inventory data, generate unique QR Codes for each item, and track item movements in real-time.

The results demonstrate significant improvements in several key areas. First, the system streamlined the inventory management process by reducing the time and effort costs of manual tracking. The automation of QR Code generation and real-time tracking not only simplified the process but also reduced the likelihood of human error, leading to more accurate records. Furthermore, the system provides enhanced visibility into the inventory lifecycle, ensuring that items can be easily located, and their usage history can be tracked comprehensively.

In addition to operational improvements, system adoption has also contributed to a reduction in the risk of item loss or misplacement, which is a common issue in manual inventory management systems. By ensuring that each item is identified and tracked uniquely, the system fosters greater accountability and reduces the potential for inventory discrepancies.

Beyond its practical application, this research makes a valuable contribution to the academic literature by addressing specific gaps identified in previous research, such as the limited application of QR Code technology in healthcare education. This study not only demonstrates the effectiveness of integrating modern technology into inventory management within academic settings but also provides a practical framework that can be adapted and customized by other educational institutions facing similar challenges.

Overall, the proposed model advances the field by offering a replicable and scalable model that goes beyond the achievements of previous research. It sets the stage for future research to explore further customization and optimization of technology-driven inventory management systems in various educational environments. This system not only enhances operational efficiency and supports the creation of a more organized, transparent, and modern educational infrastructure.

Acknowladgement

The authors would like to express their gratitude to the Institute of Publication, Research, and Community Service (LP3M) for providing valuable data for this research. We extend our sincere thanks to the Dean of the Faculty of Health for granting permission to conduct this study. Additionally, we are deeply appreciative of the entire Faculty of Engineering community for their unwavering moral and ethical support, which has greatly contributed to the successful completion of this research. Special thanks are also extended to all colleagues and participants who have provided insightful feedback and assistance throughout the research process, ensuring its smooth execution and meaningful outcomes.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper. All findings and opinions presented are based solely on the research conducted, with no influence from external parties. Any support received from institutions or individuals is acknowledged purely for the purpose of transparency and does not affect the objectivity of the study.

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