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Development of a Computerized Chemical Stock and Order Management System for Educational Institutions

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Abstract: *Stocking, ordering and managing of chemical products for testing purposes in laboratories, in an educational organization with multiple departments and large number of laboratories is a challenge as various chemicals are used in them. Different laboratories need different types of chemicals from very small quantity to large quantity. But a minimum quantity for supplying by the suppliers. Some times the requested laboratory gets 5-10 times than they requested and not utilize before the expire period, while when get a request from another laboratory for the same chemical, supplies devision of the institution repeats the same process to fulfill the order. This excess quantity stocked resulted in problems in managing, waste of money and issues in dispose. Design and implementation of a computerized chemical stock and order management system tailored for educational organizations with multiple departments and laboratories minimize waste and saves money for the organization. A simple chemical stock and order management programme can be developed for this purpose. In this project we have done it in two stages, first stage focused on designing a framework for the development of a chemical management system based on ethnographic study within the organization and in second stage involved the development of a web-based chemical management system prototype. Most required data for this, was collected through practical observations, referring past records and document, analysis and interviews with the staff specially with Laboratory Technical Officers. Chemists, Supplies officers ,lecturing staff and with research students. An analysis of the data collected from the ethnographic study, the chemical management system framework is designed. While in analysis of the framework, the key elements identified were personal and chemical safety, acquisition, classification, identification and storage of laboratory chemicals. For the maintenance of an efficient stock control system, a web based notification system is integrated at final the stage. Outcome results showed that prototype is able to accommodate the process of chemical request and stock control efficiently. The notification technique used had given effective in monitoring chemicals stocks, where the stock level falls below the predetermined minimal level or coming close to expiring soon*
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Keywords: *laboratory management, inventory, chemical management, order handling, laboratory testing, educational testing. Chemical waste, stock handling.*

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I. INTRODUCTION

1.1 Importance of chemical management in educational settings.

Chemical management in educational settings is a critical aspect of ensuring the safety and well-being of students, teachers, and staff. Educational institutions, particularly those with laboratories for science and technology subjects, handle a wide variety of chemicals that, if not properly managed, can pose significant health and environmental risks, or if not properly maintain stocks can pose waste of resources. Proper chemical management is essential to minimize hazards, comply with legal regulations, and foster a culture of safety and responsibility among all as well as to keep required stocks for lab sessions and to avoid waste of money.

1.2 Challenges faced by institutions with multiple departments and laboratories.

Managing chemicals across multiple departments in educational institutions presents significant technical and logistical challenges. The complexities of procurement, storage, regulatory compliance, and waste disposal necessitate efficient management systems to ensure safety and cost-effectiveness. Coordinating chemical orders across departments can lead to duplication, overstocking, or shortages. Without a centralized inventory system, institutions struggle with tracking chemical usage and availability, resulting in inefficiencies and increased costs. Multiple departments may have different protocols for chemical handling, leading to inconsistencies and safety risks. Effective communication and standardized procedures are essential to streamline chemical management and improve safety. Addressing these challenges requires a centralized chemical management system, strict regulatory adherence, and interdepartmental collaboration. By

implementing standardized procurement and storage protocols, institutions can enhance safety, efficiency, and compliance in multi-department chemical management.

II. OBJECTIVES OF THE PROPOSED SYSTEM

The objective of the proposed system is to develop a centralized, computerized chemical stock and order management system for educational institutions. This system will help minimize procurement costs by consolidating individual laboratory orders, allowing bulk purchasing at better prices. It will also reduce delays in supplying chemicals to relevant laboratories and minimize waste by tracking expiry dates to prevent unnecessary disposal. Centralized storage enhances safety by reducing storage risks across multiple laboratories and ensuring proper chemical management in a single location. By streamlining inventory control and optimizing order processing, the system will improve efficiency, cost-effectiveness, and safty in chemical handling.

III. LITERATURE REVIEW

III.1 Overview of existing chemical management systems

In laboratories and testing units, the chemical management system is handled manually by individual technical officers in charges of each laboratory or unit. These officers are responsible for ordering, maintaining stock, and handling chemicals, without a centralized or automated system. Due to the lack of a proper management system, chemical wastage is significantly high. Many chemical bottles remain unused and unopened until they expire, leading to a substantial waste of resources, money, and time. The inefficiency in inventory tracking results in over-purchasing and redundant stockpiling, further exacerbating the problem. Implementing an improved chemical management system can help reduce waste, optimize resource utilization, and improve overall efficiency in laboratory operations.

III.2 Gaps in current solutions for educational organizations

The currently using manual, book-based system for chemical stock and order management often lack proper categorization, real-time tracking, and accessibility for laboratory staff or research students. No centralized system for tracking stock levels, leading to duplication of orders and excess procurement due to supplier minimum quantity requirements. These manual logs or outdated databases lead to inefficiencies, misplaced stock, or delays in ordering essential chemicals Each laboratory independently manages its inventory and ordering, resulting in a lack of stock sharing and inefficient use of resources. Additionally, there is no quick or remote method to check stock availability or expiration dates, requiring physical access to record books. The absence of a central disposal system further complicates the management of expired chemicals, increasing waste and safety risks. These gaps highlight the need for a computerized solution to improve efficiency, accuracy, and resource optimization.

III.3 Proposed Solution

Proposed computerized stock and order management system will incorporate with more extra facilities, few of the features are :

Centralized Database: To manage stock levels across departments efficiently.

Sorted Storage with Bar Code/QR Code Integration: Ensuring accurate identification, tracking, and quick retrieval of chemicals.

User Access for Lab Staff & Students: Enabling them to check stock availability in real-time before placing orders.

Automated Order Management: Notifying procurement teams when stock is low, reducing delays.

Also the feature of implementing Bar Code or QR Code technology, the system will enhance accuracy, minimize errors, and improve overall efficiency in chemical stock management within the organization.

IV. SYSTEM DESIGN

IV.1 Architecture of the proposed system

The system design follows a centralized, web-based approach to ensure efficiency, accessibility, and real-time data management. It employs a client-server model where a secure database stores stock records, order histories, and expiration details, accessible through a user-friendly interface. Role-based access control allows laboratories to update stock levels, place orders, and track inventory while ensuring administrators maintain oversight. The system integrates barcode or QR code scanning for quick stock verification and automated alerts for low stock levels and approaching expiration dates. Cloud-based deployment enables remote access, promoting stock sharing among laboratories and optimizing procurement and disposal processes.

IV.2 User roles and access levels

The system implements a role-based access control model to ensure secure and efficient management of chemical inventory. Administrators have full access to manage the system, configure settings, and oversee all stock records. Technical officers in charge of relevant chemical laboratories can update stock levels, place orders, and track inventory usage. Chemists, teaching staff and research level students have read-only access to check stock availability for academic and research purposes. A "safety data sheet" (SDS) for each chemical is incorporated and linked to each chemical name, all users have access to SDS. The chemical store management team can add new chemicals, issue stock, and remove expired or excess inventory. Supply officers manage procurement, supplier interactions, and stock replenishment. User authentication is enforced through login credentials, ensuring secure access based on assigned roles, preventing unauthorized modifications, and maintaining data integrity.

IV.3 Key features

This system incorporates key features to streamline inventory control, enhance safety, and improve procurement efficiency. Real-time inventory tracking ensures accurate stock monitoring, preventing shortages and overstocking. Quick order processing and supply management optimize procurement by complying with minimum order quantities (MOQ) through combined orders, reducing excess stock and waste. Safety data management ensures proper handling and disposal of hazardous chemicals. A web-based stock notification system provides instant alerts to relevant staff about stock levels, low inventory, and approaching expiration dates. Fast-tracking capabilities enable efficient stock verification and movement, ensuring timely access to required chemicals. By integrating these features, the system enhances operational efficiency, reduces costs, and promotes a safer laboratory environment.

V. IMPLEMENTATION

V.1 Technologies used to implement the system

The implementation of a computerized chemical stock and order management system involves integrating modern technologies to ensure efficiency, security, and ease of use. The system utilizes a relational database management system (RDBMS) such as MySQL or PostgreSQL, providing structured storage for chemical inventory, order tracking, and user authentication. The database follows a centralized cloud-based model, allowing real-time access and data synchronization across multiple laboratories. The user interface is designed using web technologies like HTML, CSS, JavaScript based React or with open-source framework building web application "Angular" for a responsive and user-friendly experience. A QR code system is implemented for quick stock updates and verification, enabling users to scan chemical containers to add, remove, or check inventory details instantly. The system also includes role-based authentication, ensuring that administrators, technical officers, chemists, and supply officers have appropriate access permissions. A sample user interface features a dashboard with stock levels, order status, safety alerts, and QR code scanning functionality, enhancing usability and operational efficiency.

V.2 Steps taken to develop the system

The implementation of a computerized chemical stock and order management system follows a structured development process to ensure efficiency, accuracy, and usability. The first step is requirement analysis, where user needs, system functionalities, and security requirements are identified. Next, the system design phase involves defining the architecture, database schema, and user interface layout. The database development follows, using a relational database like MySQL or PostgreSQL to structure inventory data, orders, and user access. In the frontend and backend development phase, web technologies such as React or Angular for the UI and Node.js or Django for the backend are used to create a responsive and interactive system. The system is then integrated with QR code functionality for quick stock updates and tracking. After development, the testing phase ensures system reliability, security, and performance. Finally, the system is deployed and maintained, with continuous updates and training provided to users for smooth operation and maximum efficiency.

VI. INTEGRATION WITH EXISTING INSTITUTIONAL SYSTEMS, RECORDS AND STAFF TRAINING

The integration of a computerized chemical stock and order management system with existing manual inventory records involves a structured transition process. The first step is data migration, where inventory records from manual book-based logs are reviewed, digitized, and entered into the new database, ensuring accuracy and consistency. Barcode or QR code tagging is introduced to facilitate quick stock tracking and reduce errors. To ensure a smooth transition, staff training is conducted based on user roles. Administrators and IT personnel receive technical training on system management, database handling, and security protocols.

Laboratory technical officers and chemical store managers are trained in inventory tracking, order placement, and QR code scanning. Teaching staff and chemists receive basic training to check stock availability and request chemicals efficiently. Hands-on workshops, user manuals, and live demonstrations help ease the shift from manual to digital operations, ensuring that all users adapt to the system effectively. Continuous support and feedback sessions are provided to address challenges and improve usability.

VII. CASE STUDY

VII.1 Application of the system in a selected educational institution

In this case study, the implementation of a computerized chemical stock and order management system is examined within a selected educational institution to assess its effectiveness in improving inventory control, procurement, and safety compliance. The institution, previously reliant on a manual book-based recording system, faced challenges such as stock discrepancies, excess procurement, and difficulty tracking chemical expiration dates. The new system was introduced with a centralized database, role-based access control, QR code integration for inventory tracking, and automated notifications for stock levels and expirations. The transition process involved data migration, staff training, and gradual adoption to ensure a smooth shift from manual to digital operations. Post-implementation, the institution experienced improved inventory accuracy, reduced waste, and enhanced laboratory efficiency, demonstrating the system's value in optimizing chemical stock management.

VII.2 Feedback from users

The feedback from users, particularly management, technical staff, teaching staff, and research students, highlighted the significant improvements brought by the new computerized chemical stock and order management system. Users appreciated the system's ability to provide a quick and centralized view of inventory levels, reducing the need for manual checks and ensuring timely procurement. Related staff including teaching staff found it much easier to plan their lessons and experiments, as they could quickly check chemical availability and avoid disruptions caused by missing or expired chemicals. Research students also benefited from real-time access to stock data, enabling them to organize their experiments without delays. Chemists, Laboratory Technical Officers and other users reported enhanced efficiency in lab operations, as the system allowed for faster updates, better communication regarding chemical stocks, and automated notifications of critical stock levels or expiration dates. This seamless access to vital data fostered a more organized and proactive environment for both teaching and research activities.

VIII. RESULTS AND DISCUSSION

VIII.1 Improvements in inventory accuracy and order fulfillment

The implementation of the computerized chemical stock and order management system led to significant improvements in inventory accuracy and order fulfillment at the related chemical laboratories of the institution. Prior to the system's adoption, inventory discrepancies were common due to manual record-keeping, resulting in stock shortages or excess inventory. However, with real-time inventory tracking and automated updates, the system provided accurate, up-to-date data, eliminating errors and discrepancies. Order fulfillment also saw marked improvement, as the system streamlined the ordering process, reducing delays and ensuring that required chemicals were always in stock. The integration of QR code scanning for stock management allowed for quicker updates and real-time stock verification, further enhancing order accuracy. Overall, the system greatly optimized chemical inventory management, improving efficiency and reducing waste in laboratory operations.

VIII.2 Impact on safety and compliance with regulations

The implementation of the computerized chemical stock and order management system significantly enhanced safety and ensured compliance with regulations at the selected educational institution. By maintaining a centralized and accurate inventory, the system allowed for better tracking of chemical expiration dates, reducing the risk of using outdated or hazardous substances. Automated notifications for expiring chemicals, along with real-time stock updates, improved adherence to safety protocols. Additionally, the system's integration with safety data management ensured that relevant safety information and handling guidelines for each chemical were easily accessible to Chemists, Laboratory Technical Officers, Teaching staff and research students. The streamlined process for stock management also facilitated compliance with regulatory requirements for proper storage, disposal, and inventory control, contributing to a safer, more compliant laboratory environment.

VIII.3 User satisfaction and system usability

The implementation of the system resulted in high user satisfaction and demonstrated strong system usability across the institution. Feedback of the users indicated that the system was intuitive and easy to navigate, with a user-friendly interface that facilitated quick access to essential features such as inventory tracking, order placement, and chemical safety data. The QR code system further enhanced usability by simplifying stock updates and verifying chemical availability in real-time. Training sessions and ongoing support helped users transition from manual to digital processes smoothly, minimizing initial challenges. Overall, the system's design and functionality were well-received, leading to increased user confidence and a more streamlined, efficient approach to chemical stock management.

IX. CONCLUSION

XI.1 Summary of findings

Educational institutions currently rely on a manual, book-based inventory system to track chemical stocks and orders. This method is time-consuming, prone to human errors, and inefficient in managing resources. The new computerized system centralizes chemical stock management and order processing, ensuring real-time tracking, automated updates, and improved accuracy. Transitioning to this system involves digitizing existing records, setting up secure access for authorized personnel, and integrating automated stock level alerts. Staff will be trained through hands-on workshops, user manuals, and online support to ensure a smooth transition. This system will help educational organizations by reducing paperwork, minimizing errors, preventing stock shortages or overstocking, and ultimately saving time and resources.

XI.2 Recommendations for future enhancements and scalability

Supplier Integration: Connect directly with suppliers for automated ordering, stock updates, and pricing adjustments.
Streamlined Order Processing: Implement an online approval workflow to speed up order requests and reduce delays.
Disposal Management: Link with certified disposal organizations to ensure safe and compliant chemical waste handling.
Resource Sharing: Establish connections with other institutions to share surplus chemicals and request needed supplies, optimizing resource utilization.
These enhancements will further improve efficiency, reduce waste, and strengthen collaboration within the educational sector.

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