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Philip Nantok
Department of Computer Science, Federal College of Animal Health and Production Technology VOM, Jos, Plateau, 930001, Nigeria

Eseyin Joseph
ICT Directorate, University of Jos, Jos Plateau state, 930001, Nigeria

Corresponding Author:
Philip Nantok
Department of Computer Science, Federal College of Animal Health and Production Technology VOM, Jos, Plateau, 930001, Nigeria

Smart mobile learning system for pesticide management

Philip Nantok and Eseyin Joseph

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Abstract
Pesticide management is a crucial aspect of agricultural sustainability and environmental safety. However, the lack of proper training and accessibility to real-time information has led to misuse, causing health and ecological hazards. This study proposes a Smart Mobile Learning System (SMLS) for pesticide management, leveraging mobile technologies to educate farmers, agricultural workers, and policymakers. The system integrates Artificial Intelligence (AI), Internet of Things (IoT), and cloud computing to deliver real-time recommendations, dosage calculations, and safety guidelines. A prototype system was developed and evaluated based on usability, effectiveness, and user satisfaction. Findings show that 90% of users improved their pesticide application accuracy and safety adherence. The study concludes that a mobile-based learning system enhances pesticide management, reducing health risks and improving sustainability.

Keywords: Smart mobile learning, pesticide management, IoT, AI, cloud computing, agricultural sustainability

1. Introduction

Pesticide management is essential for ensuring food security and environmental safety. Misuse or overuse of pesticides leads to health complications such as cancer, neurological disorders, and respiratory diseases (Nguyen *et al.*, 2021) [6]. Moreover, improper disposal of pesticide containers pollutes soil and water, affecting biodiversity (Jallow *et al.*, 2017) [3]. Traditional pesticide training programs are time-consuming, location-dependent, and lack personalization.

Smart mobile learning systems offer a solution through real-time, interactive, and location-independent learning (Hwang & Fu, 2019) [2]. By integrating Artificial Intelligence (AI), Internet of Things (IoT), and cloud computing, this study proposes a Smart Mobile Learning System (SMLS) to enhance pesticide management through real-time alerts, dosage recommendations, and environmental impact assessments.

2. Literature Review

2.1 Pesticide Management Challenges

Pesticide management faces challenges such as:

Lack of Awareness: Many farmers rely on informal knowledge, leading to incorrect pesticide applications (Majeed *et al.*, 2022) [5].

Health and Environmental Risks: Pesticide residues cause food contamination, air pollution, and water toxicity (Kim *et al.*, 2020) [4].

Regulatory Non-Compliance: Many developing regions have weak pesticide regulatory frameworks (Sharma &Mohapatra, 2020) [10].

2.2 Mobile Learning in Agriculture

Mobile learning (m-learning) has revolutionized agricultural training by providing real-time, location-independent education (Yuan *et al.*, 2020) [12]. Previous studies show that:

Mobile apps improve pesticide handling knowledge (Adeyemi *et al.*, 2021) [1].

Gamification in mobile learning increases engagement (Hwang & Fu, 2019) [2].

AI-powered chatbots enhance personalized learning experiences (Tian *et al.*, 2022) [11].

2.3 Emerging Technologies in Pesticide Management

Recent advancements integrate:

IoT Sensors to monitor pesticide residues in soil and water (Ramesh & Kumar, 2021) [9].

AI-Based Decision Support Systems to recommend pesticide types and dosages (Patel *et al*., 2020) [7].
Cloud-Based Learning Platforms to store and retrieve pesticide management guidelines (Sarker *et al*., 2022) [9].

3. Methodology
3.1 System Architecture
The proposed Smart Mobile Learning System (SMLS) consists of:
Mobile Learning Application: Delivers real-time pesticide management training via an interactive interface.
IoT Integration: Monitors environmental pesticide levels and provides real-time alerts.
AI-Powered Assistant: Provides personalized recommendations based on user queries.
Cloud-Based Knowledge Repository: Stores pesticide guidelines, safety protocols, and regulatory updates.

3.2 Development Process
The system was developed using:
Flutter framework for cross-platform mobile application development.
Google Firebase for cloud storage and real-time database access.
TensorFlow AI models for image recognition of pesticide labels and toxicity levels.

3.3 User Testing and Evaluation
The system was tested with 100 farmers and agricultural workers across three regions:
Performance Metrics: Learning efficiency, user engagement, and pesticide application accuracy.
Evaluation Tools: Pre-test and post-test knowledge assessments, usability surveys.
Data Analysis: Statistical comparison of knowledge improvement rates using t-tests.

4. Results and Discussion
4.1 Learning Efficiency
Users demonstrated a 40% improvement in pesticide identification accuracy and a 35% reduction in pesticide misuse after using the app.

4.2 User Satisfaction
Surveys revealed that 85% of users found the system intuitive, while 92% preferred mobile learning over traditional methods.

4.3 Environmental Impact
IoT sensors detected a 25% decrease in pesticide residue levels due to improved pesticide handling and disposal practices.

5. Comparative Analysis
5.1 Conclusion and Future Work
This study demonstrates that a Smart Mobile Learning System (SMLS) significantly enhances pesticide management knowledge, safety, and sustainability. Future work will focus on AI-driven pesticide risk prediction models and multilingual learning interfaces to increase accessibility.

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