how mandate-driven, competence-based education can directly fuel national innovation and industrialisation. By embedding Education 5.0 principles from its inception and strategically expanding its programs–from a foundational BTech to specialized MTech degrees–the department has actively contributed to Zimbabwe's industrial agenda, proving responsive to evolving societal and technological needs. [4, 6, 12]. This trajectory reflects Crawley et al.'s [6] emphasis on experiential learning while also validating Sony's [12] call for curricula that prepare adaptive engineers for Industry 4.0 and 5.0.

Graduate outputs, start-up formation, and industrial collaborations confirm that HIT's prototype-driven pedagogy fosters technopreneurship in practice, echoing findings by Min et al. [9] that link entrepreneurship education to innovation-driven economic development. The department's contributions to key national sectors – including renewable energy, automation, telecommunications, and healthcare through biomedical engineering – show how engineering education can address pressing national challenges. This aligns with the view that African universities must be engines of development [8]. Gender imbalances (with only 17.3 % female undergraduates) mirror broader STEM disparities across Africa [19], while resource limitations and fragile pathways from prototype to full commercialisation constrain impact. As Rae [10] and others note, institutional entrepreneurship requires strong ecosystems, including financing and policy support, which remain underdeveloped in Zimbabwe.

Ultimately, the HIT model demonstrates that higher education institutions in developing contexts can successfully integrate pedagogy, innovation, and industrialisation when guided by a clear national mandate. It offers a replicable framework for other African universities aiming to move beyond knowledge transmission toward socio-economic transformation through education, innovation, and enterprise creation [1, 2].

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UDC 681

AN ICT-ENABLED UNDERGROUND MINE SAFETY SYSTEM FOR COLLISION AVOIDANCE AND REAL TIME TRACKING

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Abstract. Underground mining operations pose critical safety hazards which can be fatal. The ICT-enabled mine safety system discussed in this paper enables real-time monitoring of underground mining operations. RFID technology was utilized for real-time zonal localisation of miners and mobile equipment. GPS technology was incorporated for precise localisation. Echolocation technology was utilized for collision avoidance and alerts. A web application supported by a database is included to enable historical data acquisition as well as mining operations visualisation from a centralised control station. Implementation of this system demonstrates the potential for technology to significantly improve safety standards in the mining industry.

Keywords: mine safety, tracking, collision avoidance.

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Introduction. The mining industry has been considered as one of the industries with the highest occupational mortality rate and injuries [1]. The mining environment is characterized by complex and hazardous operations that present critical safety hazards which can lead to collisions between mobile equipment and humans or other mobile equipment causing injuries and fatalities [2]. Poor visibility in underground mines can arise due to darkness, short lines of sight and dust concentration [3].

The Safety System Building Blocks. Sensors and modules embedded on load-haul-dumpers (LHD) and personnel's personal protective equipment, software in the form of a web application and a database as well as GPS and WIFI links make up the system. An ESP32 module was used a microcontroller and Wi-Fi shield for wireless communication between hardware sensors and the remote web application for display and monitoring.

Modules Used. The RC522 RFID module was used for unique identification of miners and automobiles as well as zonal localisation. A NEO-6M GPS Module was used for precise location and L298N motor driver module with an output of 12V was implemented to effect and control motion of 5V DC geared motors of the prototype underground automobile unit.

Sensors Used. An HC SR04 ultrasonic proximity sensor was used for echolocation for collision avoidance and detection.

Output Hardware. An I2C Liquid Crystal Display displayed status updates in characters for equipment operators on the situational awareness around the LHD. Piezoelectric buzzers gave audio alerts while light emitting diodes gave visual alerts. A personal computer was used to host the database and the web application.

Microcontroller. The ESP32 was used as the core controller as well as the WIFI shield for wireless communication between the hardware sensors and the web application for display and monitoring purposes [4].

System Development. The system was developed in three sections which are; web application, tracking system and collision avoidance system

Web Application. The web application was developed on Visual Studio. The application was designed and built using HTML, CSS and JavaScript.

Tracking System. The tracking of personnel and automobiles was achieved through radio frequency identification and the Global Positioning System. Personnel and automobiles were tagged using passive RFID tags that held unique identification. Each zone was allocated an RFID reader which transmitted information of activities of the respective zone to a host computer in a control room via a web application. The control room operator is able to identify which individual or LHD entered or exited a particular zone. Every activity is recorded in a database for future reference or action. A NEO-6M GPS module was interfaced to give the actual latitude and longitude coordinates of automobile or personnel.

Collision Avoidance. Collision avoidance for the underground safety system was achieved through echolocation technology implemented using the HC-SR04 Ultrasonic sensor.

Results. Figure 1 shows the underground automobile LHD unit prototype used to demonstrate the concept.

Real Time Tracking and Location. RFID readers scanned RFID tags, registered tags had their unique identifications displayed on the LCD. GPS coordinates were delivered to the server and zoning was determined depending on which zone has been entered or exited by a particular tag.

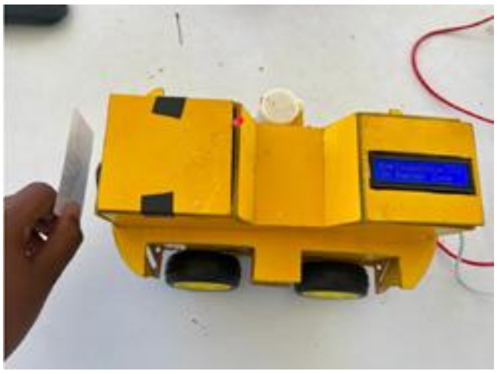

Figure 1 – The underground automobile LHD unit prototype

Integrated Safety System. Figure 2 below shows a series of successful tracking tests carried out as displayed on the web application interface. The system only displayed statistics of registered employees or automobiles.

Figure 3 shows collective data on reporting of safety breaches by a particular automobile or employee. It gives an account of each employee or automobile's accumulated safety breaches.

Figure 2 – Live Data Tracking

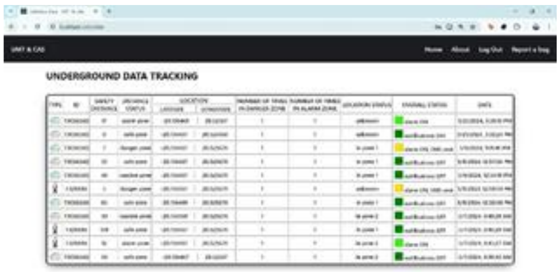

Figure 3 – Underground Tracking Data

Figure 3 illustrates in real time accumulation of times an automobile or employee encroached either the danger zone or alarm zone as well as their location in real time. It aida in identification of potential workplace hazards and risks in particular LHD operators and employees, safety breach forms can be issued to serial offenders.

Discussion And Conclusion

In this paper, an underground mine safety system for collision avoidance and real time tracking that utilizes various sensors and modules to obtain and display data in real-time has been. The safety system stands out on integrating collision avoidance and real time tracking into one system that can be implemented in underground mines to improve on safety in the workplace. By embedding the safety system on an LHD the risks associated with underground mining can be improved and productivity can be increased.

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UDC 681

EARLY CATTLE DISEASE AND OESTRUS CYCLE DETECTION USING IOT

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Abstract. This project addresses significant economic losses in dairy farming due to late disease diagnosis and poor oestrus cycle detection, issues particularly challenging for resource-limited farmers. The developed system leverages IoT technology, sensors (including temperature, heart rate, and movement), and a connected camera to monitor dairy cow health and behavioural parameters in real-time. This approach enables proactive disease detection and accurate oestrus cycle identification, facilitating prompt intervention and optimizing breeding management. Studies indicate the system achieves a 98 % decrease in disease detection time and a 95 % increase in oestrus detection accuracy compared to traditional methods. This promises enhanced agricultural productivity.

Keywords: IoT, cattle monitoring, disease detection, oestrus cycle, sensors.

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Introduction. The integration of sensing technologies and wireless networking protocols within the framework of the Internet of Things (IoT) is fundamentally transforming Precision Livestock Farming (PLF). This shift addresses the critical challenge of late disease detection and missed breeding opportunities, which often result in substantial economic losses in dairy farming. Traditional methods relying on visual inspection and conventional laboratory tests are often limited by staff availability and can lead to delayed treatment and increased disease spread.

The automated IoT-based monitoring system showcased aims to provide robust, real-time supervision of dairy cow health and the oestrus cycle. Studies supporting this approach indicate that utilizing IoT technology has resulted in a 98 % decrease in the time required for disease detection compared to traditional methods, facilitating early intervention. Additionally, the system has demonstrated a 95 % increase in the accuracy of oestrus detection, leading to improved breeding efficiency and higher milk production rates. This technology allows farmers to continuously monitor physiological parameters and behavioral patterns to identify abnormal trends or deviations before diseases progress [1].

IoT Architectures and Data Acquisition in PLF. The foundation of the system relies on carefully selected components designed for compatibility, efficiency, and size. The main controller is the ESP32-WROOM-32 microcontroller, chosen for its versatility, integrated Wi-Fi and Bluetooth Low Energy (BLE), and capacity to manage inputs from various sensors. The module features a scalable dual-core processor.

The system integrates several sensors to gather comprehensive data as shown in Figure 1:

GPS Module (NEO 6M): Tracks the cattle's geolocation. Comparisons of GPS receivers indicate that signal propagation critically influences precision.

Temperature Sensor (DHT11): Measures body temperature, noted for high precision and interference resistance.

Heart Rate Sensor (MAX30100): Monitors pulse oximetry and heart rate.

Vibration Sensor (SW 18010P): Detects changes in animal activity levels, which signal potential disease or welfare concerns.

Connected Camera (ESP32-CAM): Provides visual data capture capabilities These components form wearable devices, such as collars, that continuously collect data on vital signs and movement patterns. Real-time data collected by the sensors is analyzed for anomalies and transmitted to a cloud storage system (Firebase).

The system uses the GSM module (SIM800L) to send timely SMS alerts and notifications to the farmer via a dedicated mobile application. The microcontroller utilizes the GSM network and the mobile applica-