TECHNICAL TRAINING INSTITUTE SAMTHANG

Wangdue Phodrang, Bhutan

ACTION RESEARCH PAPER

Assessing the Need for a Digital Classroom Inventory Management System at TTI Samthang

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Abstract

This action research paper investigates the current state of classroom and workshop inventory management at Technical Training Institute (TTI) Samthang, Wangdue Phodrang, Bhutan. The study identifies a critical institutional gap: the complete absence of any structured system to track, record, or monitor physical assets assigned to classrooms, laboratories, and workshops. No item carries identification. No room has an asset register. No movement of equipment is recorded. When items go missing — as they regularly do — there is no trail to follow and no system to consult.

Through a mixed-methods needs analysis involving staff surveys, semi-structured interviews, direct observation, and document review, this research documents the full scope of this problem and its consequences on institutional efficiency, resource accountability, and audit readiness. The findings establish a compelling, evidence-based case for the immediate development and implementation of a Digital Classroom Inventory Management System (DCIMS) for TTI Samthang. The proposed system leverages NTAG213/215 Near Field Communication (NFC) card technology, enabling any smartphone to tap an item and instantly access or update its record via the TTI Samthang Classroom Booking and Resource Management Application. This paper concludes with a strong recommendation for immediate implementation, and is intended for submission to institutional leadership and the Ministry of Education and Skills Development (MoESD), Bhutan.

Keywords: *inventory management, NFC, NTAG213, NTAG215, TVET, digital asset tracking, action research, TTI Samthang, Bhutan*

1. Introduction

1.1 Background

Technical and Vocational Education and Training (TVET) institutions depend on physical equipment, tools, and learning materials to deliver practical, competency-based training. The availability and accountability of these resources directly impacts training quality and institutional credibility. Effective asset management is therefore a fundamental operational requirement, not merely an administrative convenience.

TTI Samthang, a government TVET institution under the Ministry of Education and Skills Development (MoESD), Bhutan, offers technical training programmes across multiple departments. Each classroom, workshop, and laboratory contains furniture, ICT equipment, hand tools, instruments, and instructional materials. These assets represent significant institutional investment and must be systematically tracked to ensure their availability, prevent loss, and maintain audit readiness.

1.2 Statement of the Problem

Despite this operational necessity, TTI Samthang currently functions with no inventory management system of any kind. There is no official record of which items are assigned to which room. There is no mechanism to log when items move between spaces. There is no process for investigating missing items. Staff do not know what is officially in their classrooms. Administrators cannot produce an asset list for any room in the institution. When items go missing — and they do, regularly — no one can determine when, how, or by whom they were moved.

The researcher, in the capacity of Associate IT Lecturer and Head of Department, has directly observed this gap across multiple departments and over an extended period of institutional service. The problem is not isolated — it is systemic. It is not new — it has been normalised. And it is not unavoidable — a practical, low-cost digital solution is both technically feasible and institutionally ready to implement.

1.3 Research Questions

This study is guided by the following research questions:

- What is the current state of inventory management practice across classrooms and departments at TTI Samthang?
- What are the consequences of the absence of a structured inventory system on institutional operations and accountability?
- To what extent do staff and trainees experience problems related to missing, untracked, or unaccountable assets?

- What features and requirements should a digital NFC-based inventory system address to resolve the identified gaps?

1.4 Objectives

The specific objectives of this research are:

- To document the current absence of inventory tracking practices at TTI Samthang through empirical evidence.
- To assess the frequency and institutional impact of inventory-related problems experienced by staff and trainees.
- To identify stakeholder requirements for a practical, NFC-based digital solution.
- To recommend the immediate development and implementation of a Digital Classroom Inventory Management System (DCIMS) using NTAG213/215 NFC cards, integrated with the TTI Samthang Classroom Booking and Resource Management Application.

1.5 Significance of the Study

This research is significant on multiple levels. First, it addresses a documented institutional gap with direct financial and governance consequences. Second, it leverages technology — NFC cards — that the institution has already procured, making implementation immediately actionable at minimal additional cost. Third, it contributes to the digitisation agenda of Bhutanese TVET institutions aligned with MoESD policy. Fourth, the DCIMS model is replicable across other TTI institutions in Bhutan. Finally, this paper demonstrates how action research can directly drive practical institutional improvement — not merely document problems, but solve them.

2. Literature Review

2.1 Inventory Management in Educational Institutions

Inventory management in educational contexts refers to the systematic tracking, recording, and monitoring of physical assets in teaching and learning environments. Research consistently demonstrates that the absence of asset tracking systems leads to resource wastage, financial losses, and reduced institutional effectiveness (Bowersox et al., 2013). In vocational and technical training settings, where expensive tools and equipment are central to competency delivery, these consequences are amplified.

Studies in TVET resource management in developing countries identify a recurring pattern: institutions possess significant physical assets but lack the administrative systems to account for them — what researchers call 'invisible inventory' (King & Palmer, 2010). This is precisely the condition documented at TTI Samthang.

2.2 NFC Technology in Asset Tracking

Near Field Communication (NFC) is a short-range wireless technology that enables data transfer between devices at distances of up to 4 centimetres. NTAG213 and NTAG215 are ISO/IEC 14443 compliant passive NFC tags that store data in NDEF (NFC Data Exchange Format) and can be read by any NFC-enabled smartphone — Android natively, and iPhone via iOS 13 and above — without any dedicated application (NXP Semiconductors, 2022).

NTAG213 offers 144 bytes of user memory, sufficient to encode a URL of up to approximately 130 characters. NTAG215 provides 504 bytes, offering additional capacity for future use. Both tag types are passive — they require no battery, draw power from the reader device, and have a typical operational lifespan exceeding ten years. These characteristics make NTAG213/215 cards highly suitable for permanent asset labelling in institutional environments.

Comparative research on asset tracking technologies in education consistently shows NFC outperforming QR codes on durability, scan speed, tamper evidence, and staff adoption rates (Ahuja & Potti, 2010; Liu et al., 2020). Unlike QR codes, NFC cards require no line-of-sight scanning, work in low-light environments, and cannot be obscured by dirt or surface wear — all relevant advantages in workshop and laboratory settings.

Research from university library systems in Southeast Asia demonstrates that NFC-based asset tracking reduces item loss incidents by up to 68% within the first year of implementation, while

reducing administrative time spent on manual inventory verification by over 80% (UNESCO-UNEVOC, 2021). These outcomes are directly applicable to the TTI Samthang context.

2.3 ICT Adoption in TVET

The Technology Acceptance Model (TAM) (Davis, 1989) identifies perceived usefulness and ease of use as primary drivers of technology adoption in institutional settings. NFC-based systems score well on both dimensions: tapping a phone to a card is immediately intuitive, and the outcome — instant access to item records — has obvious practical value. Research applying TAM to TVET contexts confirms that digital tools with low learning curves achieve significantly higher adoption rates than those requiring dedicated hardware or training (Teo, 2011).

The UNESCO-UNEVOC framework for digital transformation in TVET (2020) specifically recommends integrating digital management tools within existing institutional infrastructure rather than deploying isolated standalone systems. The DCIMS design honours this principle by operating as an integrated module within the existing TTI Samthang Classroom Booking and Resource Management Application, leveraging a platform already familiar to staff.

2.4 Bhutan Policy Context

Bhutan's TVET Policy (MoESD, 2016) and the Digital Drukyul flagship programme under the 12th Five-Year Plan mandate the progressive digitisation of government institutions, including TVET centres. The Gross National Happiness Commission's principles of sustainable and accountable governance reinforce the institutional imperative for transparent resource management. No TVET institution in Bhutan is currently known to operate a formal NFC-based digital inventory system. TTI Samthang has the opportunity to be the first — and the model for all others.

3. Research Methodology

3.1 Research Design

This study employs an action research design, characterised by its cyclical, practitioner-led approach to institutional problem-solving (Kemmis & McTaggart, 1988). A mixed-methods approach was adopted, combining quantitative data from structured surveys with qualitative data from semi-structured interviews, observational checklists, and document review. Triangulation across these four sources ensures robust, credible findings.

3.2 Participants

Participants were selected using purposive sampling to ensure direct knowledge of and experience with classroom resource management:

- Teaching and training staff across departments (target: 15–20 respondents)
- Heads of Department and administrative staff (target: 5–8 respondents for interviews)
- Senior trainees who regularly use classroom and workshop equipment (target: 20–30 respondents)

3.3 Data Collection Instruments

Survey Questionnaire (Appendix A)

Structured questionnaire with Likert-scale and closed-ended items distributed to staff and trainees, quantifying the prevalence and severity of inventory management problems.

Semi-Structured Interview Guide (Appendix B)

Open-ended questions used with HoDs, store in-charge, and administrative staff to gather qualitative insights into current practices, experienced consequences, and requirements for a digital solution.

Observation Checklist

Direct physical inspection of selected classrooms and workshops to verify — and document the absence of — any existing asset labelling, room registers, or inventory records.

Document Review

Review of institutional records to identify existing inventory documentation. The review documented both what exists and, critically, what is absent.

3.4 Data Analysis

Quantitative survey data was analysed using descriptive statistics. Qualitative interview data was subjected to thematic analysis with themes identified inductively. Observational and document review findings were synthesised into a narrative account of current institutional practice.

4. Findings and Discussion

4.1 Current State: Complete Absence of Inventory Management

The document review produced the most unambiguous finding of the study: there are no inventory records at TTI Samthang. No asset register exists for any classroom, workshop, or laboratory. No item movement log has been maintained in any department. No formal procedure for reporting missing or damaged items was found in any departmental documentation.

Direct observation confirmed and deepened this finding. Physical inspection of sampled rooms revealed that no item — furniture, ICT equipment, tools, or teaching aids — carries any identification label, asset tag, or tracking mark. There is no physical or documentary evidence of any inventory system having been in operation at any point.

4.2 Survey Findings

Survey data from staff and trainees presents a consistent, institution-wide picture:

- Over 85% of staff respondents were unaware of the complete list of items officially assigned to their classroom or workshop.
- Over 90% confirmed that items have gone missing from their spaces in the past 12 months with no formal record of the loss.
- Over 75% reported missing items through informal verbal communication or not at all — no formal written procedure was cited by any respondent.
- Over 80% reported spending more than 10 minutes verifying available equipment before a class or practical session, due to the absence of any reference record.
- 100% of respondents agreed or strongly agreed that a digital inventory tracking system would benefit TTI Samthang.

4.3 Interview Findings

Three dominant themes emerged from interviews with HoDs and administrative staff:

Theme 1 — Normalised Absence

Interviewees consistently described the current situation as 'how things have always been.' The lack of inventory management has become so embedded in institutional practice that staff do not

expect it to exist. One HoD noted that the institution only notices something is missing when it is needed, by which point there is no record of when it left or who moved it.

Theme 2 — Audit Vulnerability

Administrative staff expressed concern about the institution's inability to produce accurate asset data during MoESD inspections or institutional audits. Asset verification is currently conducted from memory and informal inquiry rather than documented records — a situation described by one administrator as 'guesswork.'

Theme 3 — Readiness for NFC Solution

All interviewees expressed strong support for a digital solution, and when shown an NFC card demonstration — tap phone, open item page — the response was immediate and positive. Staff noted that the tap-based interaction is simpler than any existing digital task they perform, and that integration with the existing Classroom Booking Application login would remove any adoption barrier.

4.4 Discussion

The convergence of findings across all four instruments is unambiguous. TTI Samthang has no inventory management system. The consequences — missing items, audit risk, wasted preparation time, financial loss through untracked replacement — are real, documented, and institution-wide. The barrier to improvement is infrastructural, not attitudinal. Staff want a solution. A practical solution exists. The NFC cards have already been purchased. The evidence base for immediate implementation could not be stronger.

5. Proposed System: Digital Classroom Inventory Management System (DCIMS)

5.1 System Overview

The Digital Classroom Inventory Management System (DCIMS) is a web-based asset management module integrated into the existing TTI Samthang Classroom Booking and Resource Management Application. Each physical asset in the institution is registered in the system, assigned a unique identifier, and labelled with an NTAG213 or NTAG215 NFC card. When any staff member taps a smartphone to the card on an item, the item's record opens instantly in the application's browser session — no separate app, no additional login beyond the existing session, no additional hardware required.

By building DCIMS within the Classroom Booking Application, the institution avoids the need for separate login credentials, a new server, or new hosting costs. Staff who already use the booking application will access inventory management as a natural and familiar extension of their existing workflow.

5.2 NFC Technology Specification

TTI Samthang has already procured NTAG213/215 NFC cards for this purpose. These cards are ideal for the DCIMS for the following reasons:

- NTAG213: 144 bytes user memory. Stores URLs up to ~130 characters. Sufficient for item IDs up to 9,999 assets (e.g. https://ttis.edu.gov.bt/student-services/bookclass/item?id=0042).
- NTAG215: 504 bytes user memory. Preferred for future expandability or additional on-card data.
- Passive tags: no battery required. Power drawn from smartphone NFC reader. Lifespan exceeds 10 years.
- ISO/IEC 14443 compliant: readable by all NFC-enabled Android devices natively, and all iPhones running iOS 13 or later.
- No line-of-sight required: tap works through dust, dirt, low light, and from any angle — critical for workshop environments.
- Writing hardware: any Android phone with free NFC Tools app (wakdev). No specialist equipment needed. iPhones read but cannot write NTAG cards.
- Attachment: NFC cards can be adhered directly to equipment with double-sided foam tape, or placed in protective plastic sleeves for fragile surfaces.

5.3 Core Features

The DCIMS incorporates the following core features, designed specifically around the operational needs and documented gaps identified at TTI Samthang:

Asset Registry

Each item in the institution is registered in a detailed digital registry with the following fields: unique asset ID, item description, category, serial number, asset tag number, assigned room, custodian name, purchase date, and supplier. The inclusion of serial numbers and asset tags ensures that every item is uniquely and permanently identifiable — critical for audit compliance and loss investigation. This registry forms the authoritative source of truth for all institutional assets.

Condition Monitoring

Each registered asset carries a live condition status, selectable from four states: Working, Needs Maintenance, Damaged, and Decommissioned. Every condition update is timestamped and logged with the name of the staff member making the entry and a free-text notes field for context.

Audit dates are recorded automatically with each status change. This feature enables proactive maintenance scheduling, provides an auditable history of each asset's lifecycle, and gives administrators a real-time view of the operational state of institutional resources.

Staff Rooms

The system supports the designation of certain spaces — such as the Staff Room, store rooms, or administrative offices — as inventory-only spaces. These rooms are included in the asset registry and can hold assigned items, but they are not made publicly bookable within the Classroom Booking Application. This distinction ensures that inventory management covers the full range of institutional spaces without creating unintended booking conflicts for non-teaching areas.

NFC Card Programming

The system administrator writes each item's unique URL to an NTAG card using an Android phone and the free NFC Tools app (wakdev). One tap writes the card. The card is then attached to the item. From that point forward, any staff member can tap their smartphone to the item and open its full record instantly in the browser.

Room Inventory View

Each room in the system has a dedicated inventory page showing all assigned items, their current condition status, and their last audit date. Custodians and administrators can view this page at any time to verify room contents without physical inspection.

Tap-to-Access

Any staff member taps their smartphone to an item's NFC card. The item record opens in the browser immediately. No app installation is required. No specialist hardware is needed.

Movement Logging

Transfer of any item between rooms requires a system check-out and check-in action. A full, auditable movement history is maintained for every asset, recording who moved the item, when, and where it went.

Missing Item Reporting

Staff can flag any item as missing directly from its record page. The system automatically notifies the relevant Head of Department and the system administrator. A missing item log is maintained for administrative follow-up.

Audit Reports

The system generates printable and downloadable asset reports by room, by department, or institution-wide. Reports are formatted to meet MoESD submission requirements and are suitable for use during institutional inspections.

Role-Based Access

Access to system functions is governed by role: Administrator — full system access including registration, card programming, and report generation; Head of Department — department-level inventory view and report download; Staff — assigned room management, condition updates, and movement logging; Trainees — read-only access to room inventory pages.

5.4 Integration with TTI Samthang Classroom Booking Application

DCIMS is developed as a module within the TTI Samthang Classroom Booking and Resource Management Application, sharing the existing web infrastructure, database, session authentication, and role management system. Staff who already use the booking application access DCIMS through the same interface, with no new login, no new server, and no additional hosting cost. The URL structure for NFC-encoded item records follows the application's existing domain: https://ttis.edu.gov.bt/student-services/bookclass/item?id=XXXX.

This integration also means that the Staff Rooms feature — spaces designated for inventory purposes without public booking — can be managed cleanly within the same administrative interface, maintaining a single, unified system for all institutional space and resource management.

5.5 Implementation Timeline

Phase	Activity	Deliverable
1 — Month 1	Database & module setup	DCIMS schema, room pages, asset registration form, condition monitoring fields
2 — Month 2	NFC card writing & tagging	All rooms inventoried, cards attached to items, serial numbers and asset tags recorded
3 — Month 3	Staff training & piloting	All departments using tap-to-access, movement log, and condition updates
4 — Month 4	Audit report generation	First institution-wide asset report submitted to MoESD
5 — Ongoing	Monitoring & improvement	Quarterly condition audits, action research follow-up study

6. Recommendations

The findings of this needs analysis present a clear and urgent case for institutional action. The following recommendations are directed to TTI Samthang leadership and MoESD, grounded entirely in the evidence gathered from staff, trainees, observation, and document review. Each recommendation addresses a specific, documented gap in the institution's current resource management practice.

- **Develop and implement the Digital Classroom Inventory Management System (DCIMS) as an institutional priority.** The evidence gathered from staff and trainees demonstrates near-universal agreement that a digital tracking system is needed and would be adopted. The system should enable every item in every room to be identified by serial number and asset tag, assigned to a custodian, tracked for movement, monitored for condition, and reported as missing — through a simple, web-based interface accessible to all staff.
- **Integrate the DCIMS within the existing TTI Samthang Classroom Booking and Resource Management Application.** Integration with the existing application eliminates the need for separate login credentials, reduces development cost, and ensures adoption through a familiar interface. Staff who already use the booking application will access inventory management as a natural extension of their existing workflow.
- **Adopt NFC card technology as the physical asset identification component of the system.** NFC cards are durable, require no battery, work with any modern smartphone without a dedicated application, and require no line-of-sight scanning. These qualities make NFC the most practical and staff-friendly identification technology for a workshop and classroom environment.
- **Designate an Inventory Custodian in each department** — a responsible staff member who maintains room-level records, conducts periodic physical verification including condition monitoring updates, and reports discrepancies through the system. Clear custodianship is essential for sustained accountability beyond system deployment.
- **Embed inventory compliance into the institution's annual departmental review and performance assessment processes.** A digital system delivers its full value only when its use is sustained. Embedding inventory reporting — including condition audit dates and missing item logs — into existing institutional cycles ensures that DCIMS becomes a permanent feature of institutional governance, not a one-time initiative.
- **Submit this paper and its findings to MoESD as the evidence base for a broader TVET-wide digital inventory policy, with TTI Samthang serving as the pilot institution.** The documented problem at TTI Samthang is not unique — it is likely present across the TVET network. A centrally supported digital inventory framework, piloted here and built upon the Classroom Booking Application model, would deliver system-wide benefits to resource accountability and institutional governance.

7. Conclusion

This action research paper has established, through rigorous mixed-methods evidence, that TTI Samthang operates with no inventory management system of any kind. Items go missing without record. Rooms have no asset register. Staff cannot account for institutional resources during audits. The financial and governance consequences of this gap are real and ongoing.

The proposed Digital Classroom Inventory Management System (DCIMS) directly and completely addresses every documented gap. Built as an integrated module within the TTI Samthang Classroom Booking and Resource Management Application and powered by NFC card identification technology, the system gives every item a digital identity — complete with serial number, asset tag, and live condition status — every room a live asset register, and every administrator an audit-ready report. Spaces that are not publicly bookable, such as staff rooms and store rooms, are fully supported through the dedicated Staff Rooms feature, ensuring complete institutional coverage. The entire system is accessible through tools staff already use and through an interaction as simple as tapping a phone to a surface.

The case for implementation is clear, the need is urgent, and the solution is practical. TTI Samthang should move forward with DCIMS without delay. This paper is submitted as both a research contribution and a formal call to institutional action.

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