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"Users' Perception of the i-TOOLS (Intelligent Tool Storage System) in the Woodworking Workshop: A Quantitative Survey and Dual-Center Evaluation at Politeknik Melaka and Politeknik Merlimau"

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Abstract

This research evaluates the operational effectiveness and cross-institutional field performance of the i-TOOLS (Intelligent Tool Storage System) for hand tool management in Woodworking Workshops under the Department of Civil Engineering at two polytechnics in the Southern Region of Malaysia: Politeknik Melaka (PMK) and Politeknik Merlimau (PMM). Adopting a quantitative dual-center cross-sectional survey research design, this research engaged a total sample of 64 respondents, comprising 58 Semester 1 students enrolled in the DCC10273 Building Construction course and 6 lecturers across both institutions. Utilizing standardized five-point Likert scale questionnaires tailored for both students and lecturers, this research measures user perceptions regarding tool loss reduction, procedural acceptance, pedagogical value, and cost feasibility. Students from both institutions participated in the evaluation of the i-TOOLS system in their practical woodworking workshop context. Quantitative data analysis using descriptive frequencies and percentages revealed positive perceptions regarding tool loss prevention, with 56 out of 58 students (96.6%) agreeing that i-TOOLS helps reduce hand tool loss or misplacement. Furthermore, all 58 student respondents (100.0%) agreed with the tool-return procedure implemented through the i-TOOLS system. Descriptive statistical analysis of responses from the 6 lecturers indicated that all lecturers (100.0%) selected "Strongly Agree" for each item in the lecturer questionnaire, reflecting highly positive perceptions of the system's potential to reinforce student workplace discipline, support the prevention of missing tools and associated replacement costs, and serve as a teaching aid (ABM) for first-semester TVET students.

Keywords: i-TOOLS, Hand tool management, Woodworking workshop, Tool storage, Polytechnics in Melaka.

1. Introduction

1.1 Background of the Study

Within the framework of Technical and Vocational Education and Training (TVET), practical workshop environments serve as a foundational pillar for pedagogical delivery. These spaces are uniquely designed to bridge the gap between theoretical classroom concepts and authentic, real-world industry applications by providing students with essential tactile learning opportunities and hands-on technical exposure. Beyond the acquisition of specialized mechanical capabilities, continuous engagement in structured workshop operations cultivates higher-order cognitive competencies, such as collaborative teamwork, practical problem-solving methodologies, personal accountability, and strict operational discipline. Consequently, the enforcement of rigorous, comprehensive, and highly systematic workshop management protocols stands as a non-negotiable imperative to ensure that all academic and practical modules proceed seamlessly, securely, and without logistical interruptions.

In the specific context of institutional woodworking laboratories, hand tools—ranging from basic impact equipment like hammers to precision instruments such as linear measuring tapes, structural L-squares, and various specialized screwdrivers—are continuously utilized across a diverse spectrum of fabrication phases. These phases typically encompass material measurement, layout marking, cutting operations, component fastening, structural assembly, and final surface treatment. Given the dense laboratory schedules where extensive cohorts of students share a finite pool of equipment simultaneously, the deployment of a highly organized tool storage framework is crucial to preserve immediate equipment accessibility, ensure uniform arrangement, and maintain high tool availability for upcoming instructional groups.

Despite its documented importance, the manual administration of shared tool inventories within large-scale training workshops introduces persistent operational vulnerabilities. Common complications frequently include the accidental misplacement of small components, unrecorded tool borrowing, equipment being returned to improper storage slots, or tools simply being abandoned at individual student workbenches post-session. When a storage framework lacks automated tracking mechanisms, both instructional faculty and laboratory technicians are forced to squander critical instructional hours conducting exhaustive manual headcounts to trace missing inventory. This logistical bottleneck routinely disrupts tight workshop schedules, severely delays end-of-class cleanup and security closing sequences, and directly encroaches upon the qualitative contact time allocated for teaching and learning activities. Furthermore, cumulative tool losses impose a continuous financial strain on institutional operational budgets due to repetitive replacement expenditures, while simultaneously inflating the administrative workload of workshop staff.

To systematically mitigate these inefficiencies, the i-TOOLS (Intelligent Tool Storage System) has been introduced as an innovative, technologically integrated hardware solution specifically engineered for the Woodworking Workshop environment. The structural architecture of i-TOOLS moves away from passive storage by utilizing physical sensor switches mapped to designated slots, linked directly to an automated audio-visual verification sequence. This system design aligns with advanced tracking concepts in vocational environments, such as the ubiquitous computing frameworks demonstrated by Sulistyo et al. (2022), which emphasize how automated asset management improves resource visibility and institutional efficiency. Upon triggering the master switch during the end-of-session inventory checkout, the i-TOOLS system provides immediate, actionable feedback: a localized auditory buzzer combined with an active red LED indicator instantly highlights any missing or misaligned tool, whereas a uniform green LED configuration confirms that all assets are fully accounted for and correctly placed.

To establish the operational validity and scalability of this innovation across a broader academic landscape, this research expands its empirical investigation beyond its primary testing site at Politeknik Melaka (PMK) to include a comparative evaluation at Politeknik Merlimau (PMM). This multi-center field deployment achieves rigorous experimental control due to the complete standardization of the academic curriculum across the Malaysian Polytechnic network. Because first-semester Civil Engineering (JKA) students at both PMK and PMM are bound by the identical syllabus requirements of the DCC10273 Building Construction course, they face identical tool management challenges, handle the exact same class sizes, and utilize equivalent workshop assets. By executing a fully quantitative cross-sectional survey design following active, hands-on physical interaction with the i-TOOLS apparatus at both campuses, this research provides a highly generalizable and

methodologically sound evaluation of smart tool management systems within the modern TVET ecosystem.

1.2 Research Objectives

The primary objectives of this study are structured around specific operational milestones as follows:

i. To evaluate users' perceptions regarding the operational effectiveness of the physical i-TOOLS deployment in mitigating asset displacement and reducing hand tool losses within the Civil Engineering Woodworking Workshops at Politeknik Melaka (PMK) and Politeknik Merlimau (PMM).
ii. To assess the level of user acceptance, procedural compliance, and behavioural adaptation among first-semester civil engineering students regarding the mandated, technology-enforced routine of returning shared equipment to its designated electronic slots within the i-TOOLS hardware framework upon the conclusion of laboratory sessions.
iii. To determine the institutional consensus among academic lecturers across both campuses concerning the macro-level implications of physical i-TOOLS integration, with a specific focus on its impact on student workshop discipline, its utility as an interactive pedagogical tool (ABM), its capacity for operational cost protection, and its overall scalability for cross-departmental replication throughout alternative technical training laboratories.

2. Literature Review

2.1 Workspace Optimisation and the Falsafah of 5S Protocols

The institutionalization of the 5S framework—comprising Sort, Set in Order, Shine, Standardise, and Sustain—serves as a standardized benchmark for establishing operational efficiency and systemic safety within technical training environments. Scholarly evaluations by Gupta (2022) demonstrate that the methodical implementation of these five pillars directly correlates with enhanced institutional productivity, optimal equipment lifecycle management, and a significant reduction in operational downtime. Within the operational parameters of civil engineering laboratories, the Set in Order (systematic arrangement) metric is exceptionally vital. Shared implements, including impact apparatuses and precision measuring devices, must be assigned immutable spatial boundaries to prevent operational chaos. Furthermore, academic reviews by Randhawa and Ahuja (2017) indicate that physical storage frameworks alone cannot guarantee sustainable compliance; rather, continuous user enforcement and standardized feedback routines are mandatory to transform temporary compliance into long-term organizational habits. Consequently, the integration of structural storage frameworks like i-TOOLS acts as an electronic facilitator for the Standardise and Sustain metrics by embedding mandatory check-out loops into the laboratory concluding sequence.

2.2 Inventory Integrity and Asset Availability Dynamics

Preserving total inventory integrity within educational workshop environments is an essential prerequisite for maintaining the continuity of practical teaching delivery. When technical assets are subjected to simultaneous multi-user demands, traditional manual auditing methods frequently fail, resulting in tool displacement, delayed laboratory

schedules, and an inflated administrative burden for faculty members. Empirical evidence presented by Pratomo et al. (2025) underscores that the optimization of asset availability directly impacts the overarching performance metrics of a technical workshop. Similarly, research in ergonomic storage architecture by Esmayatim and Jamian (2026) corroborates that combining specialized storage configurations with visible labeling schemas or physical position-verification hardware drastically curtails retrieval bottlenecks. However, because structural designs vary extensively across the academic literature, the specific electronic sensor features and automated auditing mechanisms embedded within the i-TOOLS apparatus must be evaluated based on localized multi-center performance rather than baseline theoretical assumptions.

2.3 Hand Tool Management Frameworks in Vocational Training Ecosystems

Vocational engineering laboratories function as critical pedagogical arenas where students are expected to acquire not only mechanical competencies but also professional workplace ethics, safety awareness, and individual accountability. Within woodworking modules, the intensive usage of shared hand tools requires a robust, structured tracking mechanism to prevent chronic equipment depreciation and loss. Traditional management models often suffer from a visibility gap, where misplaced tools are only discovered hours after the student cohorts have departed the facility. Automated storage systems fill this operational gap by integrating tool auditing into the immediate post-session routine. By transforming tool sorting into an interactive, structured requirement, technological solutions foster a culture of collective responsibility. Moreover, proper tool administration is fundamentally intertwined with occupational safety protocols, as unsecured tools abandoned on heavy machinery or walking pathways introduce severe physical hazards to subsequent laboratory users.

2.4 The Impact of Audio-Visual Feedback Loops on User Compliance Behavior

Modern educational technology increasingly relies on immediate feedback mechanisms to guide user behavior and reinforce workplace discipline. According to recent studies in industrial ergonomics and behavioral compliance by Ahmad and Mohamad (2024), human error and oversight in asset return routines are significantly reduced when storage frameworks move away from passive indexing to active, sensory-driven intervention. The deployment of dual-channel sensory signaling—specifically the synchronous utilization of localized auditory buzzers and high-visibility LED color alterations (red and green configuration)—acts as an immediate psychological prompt. This immediate behavioral reinforcement mechanism bypasses cognitive fatigue, compelling student operators to correct storage errors instantly before terminating their shift. In an educational workshop setup, utilizing active sensory feedback loops effectively automates the enforcement of 5S regulations, turning standard safety checklists into an automated, error-free operational routine.

2.5 Strategic Research Gap and Justification

Although existing literature discusses 5S, inventory management, and tool storage design, empirical evidence on users' perceptions of the i-TOOLS system in Malaysian polytechnic woodworking workshops remains limited. This study addresses this gap using Google Forms survey responses from students and lecturers at Politeknik Melaka (PMK) and Politeknik Merlimau (PMM). The findings describe perceived usefulness and acceptance; they do not independently establish a measured reduction in actual tool-loss rates or costs.

3. Methodology

3.1 Research Design

This research employs a quantitative, cross-sectional survey research design to evaluate the field operational performance of the i-TOOLS apparatus across multiple institutional centers. This descriptive approach was selected to capture empirical data simultaneously from two distinct vocational training environments. By applying standardized metric instruments, the design systemically measures, analyzes, and compares user perceptions, structural workflow acceptance, and macro-level institutional benefits without introducing active historical bias into the practical setting

3.2 Strategic Research Sites

Empirical data collection and physical hardware deployments were executed in parallel at two technical institutions within the Southern Region of Malaysia:

- Politeknik Melaka (PMK) – Serving as the primary testing laboratory facility and baseline control environment.
- Politeknik Merlimau (PMM) – Serving as the secondary deployment center to validate cross-institutional scalability.

The selection of these specific sites establishes rigorous experimental control due to the complete standardization of the academic curriculum across the Malaysian Polytechnic network. First-semester Civil Engineering students at both PMK and PMM are bound by identical syllabus regulations, manage equivalent class capacities, perform the same practical workshop modules for the DCC10273 Building Construction course, and utilize uniform tool inventories.

3.3 Participant Sampling and Cohort Profile

A total of 64 respondents submitted the Google Forms questionnaire. The sample comprised 58 students enrolled in DCC10273 (33 at PMK and 25 at PMM) and 6 lecturers (3 at each institution). The respondents were included through a non-probability, purposive/convenience approach based on their participation in the i-TOOLS evaluation.

- Student cohort (n = 58): 33 students from PMK and 25 students from PMM, enrolled in DCC10273.
- Lecturer cohort (n = 6): 3 lecturers from PMK and 3 lecturers from PMM.

The Google Forms export records 64 responses in total. Student and lecturer items were presented to the relevant respondent groups; therefore, not all items have 64 responses.

Table 1 : Category of participants

Participant Category	Politeknik Melaka (PMK)	Politeknik Merlimau (PMM)
Semester 1 Students (DCC10273)	33	25
Civil Engineering Lecturers	3	3
Institutional Cohort Total	36	28

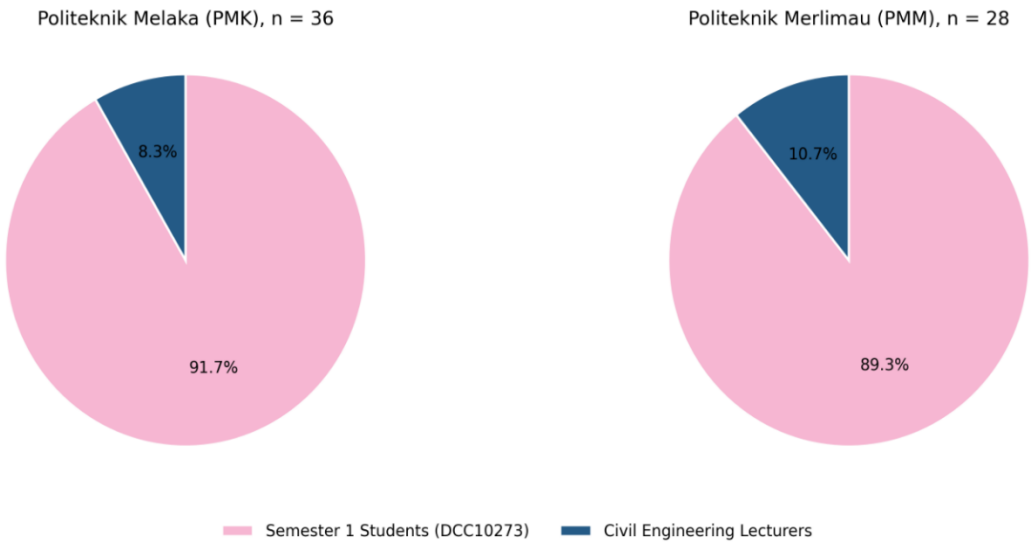


Figure 1 : Pie chart of category of participants

3.4 Research Instrumentation and Technical Apparatus

The empirical measurement framework integrates a specialized technological hardware unit with dual-channeled quantitative survey instruments.

3.4.1 i-TOOLS Hardware Specifications

The Intelligent Tool Storage System functions as the core physical intervention. Structurally, it features localized mechanical sensor switches mapped to dedicated physical slots for small hand tools (hammers, measuring tapes, L-squares, and screwdrivers). Upon activating the master verification switch at the end of a laboratory session, the integrated electronic circuit executes an automated inventory audit. Any asset displacement or incomplete tool return triggers an immediate dual-channel sensory signaling loop, deploying an active localized auditory buzzer alongside high-visibility red LED color alterations. Conversely, a uniform green LED configuration establishes total inventory integrity, permitting workshop closure.

3.4.2 Quantitative Survey Framework

The Google Forms questionnaire used five-point Likert response options. The student section contained statements on perceived tool-loss prevention, sensor indicators, tool checking, organization, understanding of return procedures, acceptance of tool-return requirements, responsibility, ease of use, and error correction. The lecturer section contained statements on discipline, responsibility, workshop organization, teaching-aid value, safety practices, cost implications, and transferability to other workshops.

3.5 Field Operational Procedure

The multi-center empirical evaluation was executed across five distinct chronological phases to guarantee high operational consistency:

• Phase 1 (System Deployment & Orientation): Physical i-TOOLS hardware units were mounted within the woodworking laboratories of both polytechnics. Instructors and students attended standardized technical orientations explaining tool-placement criteria and circuit activation rules.

• Phase 2 (Active Workshop Fabrication): Students engaged in mandatory practical woodworking and fabrication tasks under normal syllabus parameters, drawing shared tools from the inventory pool.

• Phase 3 (Automated Post-Session Auditing): At the end of the practical activities, students returned the tools to their designated sensor slots. Supervisors then activated the master switch to verify the tool positions. If any tools were missing or incorrectly placed, the system triggered a red LED indicator and an audible alarm, prompting students to rectify the issue immediately.

• Phase 4 (Google Forms Survey): The questionnaire was administered electronically. The exported spreadsheet contained 64 responses: 58 student responses and 6 lecturer responses across PMK and PMM.

• Phase 5 (Data Consolidation): Completed instruments were gathered, cross-checked for completeness, and coded into numerical datasets for statistical computation.

3.6 Quantitative Data Analysis

Raw numerical data extracted from the Likert scales were compiled and analyzed utilizing descriptive statistical metrics. Quantitative analysis focused on calculating descriptive frequencies and percentage distributions (%) to determine user agreement margins for each operational variable. The specific mathematical equation utilized to compute the cohort agreement margins is defined as follows:

Positive response (%) = (Number of Agree + Strongly Agree responses / Number of valid responses for that item) * 100

Descriptive statistical data generated from the faculty cohort were processed independently to track the exact degree of institutional consensus regarding macro-level benefits. Final results were organized into comparative dual-center frameworks (PMK vs. PMM) to establish statistical consistency and verify whether the sensory-driven hardware operates uniformly across different educational environments.

4. Results and Discussion

4. Results and Discussion

This section reports the Google Forms data collected from 64 respondents during October 2026: 58 students (33 at PMK and 25 at PMM) and 6 lecturers (3 at each institution). Student items were answered by the student cohort, while lecturer items were answered by lecturers. Results are descriptive and reflect respondents' perceptions of i-TOOLS.

4.1 Quantitative Survey Outcomes

4.1.1 Cross-Center Student Perceptions on Hand Tool Loss Mitigation

The primary research milestone focused on evaluating the perceived efficacy of the active audio-visual tracking architecture of i-TOOLS in mitigating the misplacement and loss of workshop equipment. Quantitative survey reflections indicate a highly consistent positive pattern across both technical campuses.

Descriptive percentage analysis indicates that a vast majority of the student cohort expressed positive feedback, with 96.6% (n = 56) of the combined respondents agreeing that the deployment of i-TOOLS effectively reduces the risk of hand tool loss within the Civil Engineering woodworking workshops. Broken down by campus, 32 of 33 PMK students (97.0%) and 24 of 25 PMM students (96.0%) selected Agree or Strongly Agree. Conversely, a minimal 3.4% (n = 2) of the combined sample provided a neutral remark regarding this metric. The distinct visual indicators embedded within the system—specifically the automated alarm mechanism, red status illumination for anomalies, and green illumination validating full inventory integrity—collectively support users in executing rapid and precise inventory audits before exiting the facility.

Table 2 : Students perception of i-Tools for tool-loss prevention

Category	Politeknik Melaka (PMK)	Politeknik Merlimau (PMM)	Combined Sample
Agree / Strongly	32 (97.0%)	24 (96.0%)	56 (96.6%)
Neutral	1 (3.0%)	1 (4.0%)	2 (3.4%)
Total	33 (100%)	25 (100%)	58 (100%)

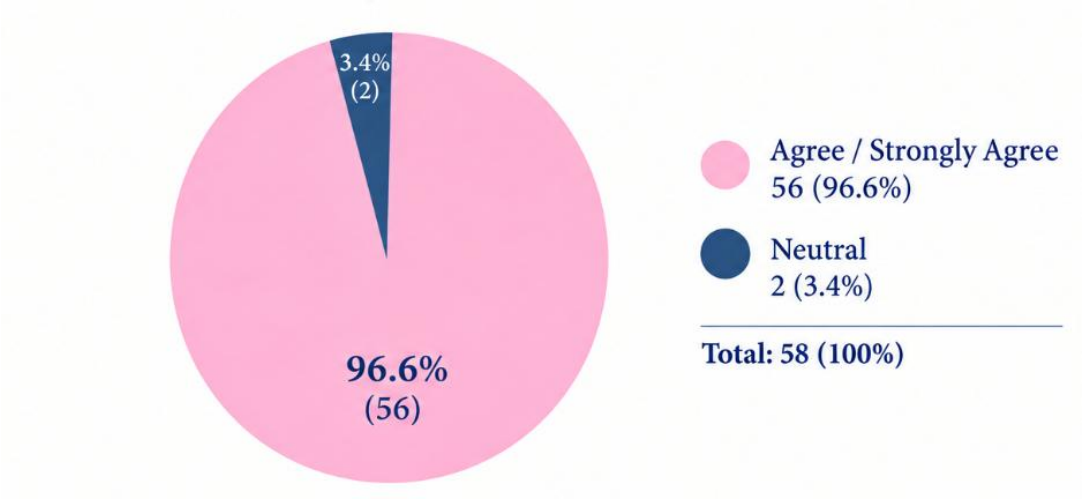


Figure 2 : Pie chart of student perceptions on hand tool loss reduction through i-TOOLS

4.1.2 Behavioral Compliance and Tool-Return Workflow Acceptance

The second operational milestone measured student acceptance and behavioral adaptation regarding the mandated tool-return routine. The metric reflected an absolute level of institutional compliance and student readiness, with 100.0% (n = 58) of the total student population explicitly agreeing with the structured tool-return workflow managed by the i-TOOLS hardware.

Looking closely at the cross-sectional distribution, the survey yields a complete consensus level of 100.0% (33/33) at Politeknik Melaka, and 100.0% (25/25) at Politeknik Merlimau. There were zero registered instances of non-compliance or disagreement across the entire combined student cohort. Every student respondent successfully validated the operational integration of returning shared woodworking assets to their assigned digital storage slots at the end of practical assignments. This absolute acceptance suggests that the inclusion of electronic validation procedures does not introduce cognitive friction; instead, it establishes an organized, clear checklist that reinforces students' individual accountability.

Table 3: Student operational acceptance regarding the i-TOOLS return procedure

Workflow Compliance Level	Politeknik Melaka (PMK)	Politeknik Merlimau (PMM)	Total Combined Margin
Full Acceptance / Agreed	33 (100.0%)	25 (100.0%)	58 (100.0%)
Non-Compliance / Disagreed	0 (0.0%)	0 (0.0%)	0 (0.0%)

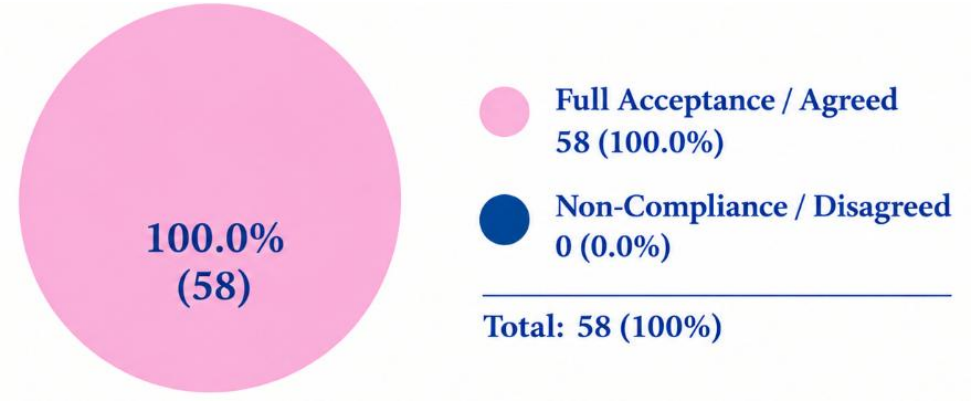


Figure 3: Pie chart of student operational acceptance regarding the i-TOOLS return procedure

4.2 Institutional Faculty Consensus and Thematic Analysis

Descriptive evaluation parameters extracted from the 6 experienced academic instructional staff members (3 at PMK, 3 at PMM) indicated a 100% consensus across four macro-level operational dimensions. Faculty feedback confirms that the integration of the i-TOOLS apparatus provides substantial benefits beyond simple asset indexing.

• Educational Infrastructure Value (Teaching Aid Efficacy): The entire faculty cohort confirmed that the i-TOOLS unit serves as an excellent pedagogical aid (Alat Bantu Mengajar - ABM). For first-semester TVET students who are often unfamiliar with laboratory safety protocols, the active sensory signaling guides correct tool recognition and accelerates the internalization of proper workshop storage habits from the beginning of their studies.

• Workplace Discipline and Safety Enforcement (Behavioral Conditioning): Faculty members emphasized that shifting the checking sequence from a passive checklist to an active audio-visual verification framework dramatically enforces student discipline. The requirement to clear all red indicators before terminating a laboratory shift fosters collective responsibility and prevents tool abandonment at workbenches.

• Long-Term Public Asset Protection (Operational Feasibility): Both institutional groups noted that the physical implementation of i-TOOLS offers critical operational cost protection. By preventing cumulative tool loss and minimizing recurring institutional budget allocations for inventory replacement, the platform demonstrates high long-term financial viability for public educational centers.

• Cross-Departmental Replication Potential (Systemic Scalability): Lecturers across both locations uniformly agreed that the underlying architecture of i-TOOLS is highly scalable. The system can be easily adapted to other vocational training environments that rely on small hand tools, such as welding, automotive, or electrical installations, by adjusting the mechanical sensor mappings.

4.3 Comprehensive Analytical Discussion

The empirical results demonstrated that student perceptions of i-TOOLS were highly positive across both institutions. Specifically, positive responses reached 96.6% (56/58) for tool-loss

prevention and an absolute 100.0% (58/58) for the mandated tool-return requirement, supported by unanimous strong agreement from the lecturers. This consistent pattern highlights the system's effectiveness as a structured behavioral prompt within technical workshops.

However, since this research relies on self-reported survey data from a limited multi-center sample, the findings reflect users' positive perceptions rather than objective physical metrics. Future research should incorporate longitudinal tool-loss logs, time-motion studies, and precise cost-replacement records to quantitatively validate the system's long-term financial and operational impact.

5. Conclusion

This research evaluated user perceptions of i-TOOLS in the Woodworking Workshops at Politeknik Melaka and Politeknik Merlimau using 64 Google Forms responses: 58 students and 6 lecturers. The student sample comprised 33 respondents from PMK and 25 from PMM; the lecturer sample comprised three from each institution. For perceived reduction of tool loss or misplacement, 56 of 58 students (96.6%) selected Agree or Strongly Agree. The positive-response proportions were 97.0% at PMK (32/33) and 96.0% at PMM (24/25). This indicates a high level of perceived usefulness, but actual tool-loss rates were not independently measured. Acceptance of returning tools to designated slots was absolute: All 58 students (100.0%) responded positively, including 33/33 (100.0%) at PMK and 25/25 (100.0%) at PMM.

All six lecturers strongly agreed with the lecturer-section statements on discipline, responsibility, organization, teaching-aid value, safety, potential cost benefits, and transferability to other workshops. These findings support further evaluation of i-TOOLS, while the small sample and self-reported nature of the data mean that claims about actual cost savings and reductions in tool loss require objective follow-up measurements. In conclusion, i-TOOLS has the potential to improve hand tool management in polytechnic woodworking workshops by encouraging proper tool-return practices and supporting users' awareness of responsible tool management.

6.Reference

Abd Halim, N. N., & Jamian, R. (2025). Improving storage organization through 5S practices in a welding workshop. Progress in Engineering Application and Technology, 6(2), 298–306. https://penerbit.uthm.edu.my/periodicals/index.php/peat/article/view/21043

Abdul Rahim Hamdan, & Hayazi Mohd Yasin. (2010). Penggunaan alat bantu mengajar (ABM) di kalangan guru-guru teknikal di Sekolah Menengah Teknik Daerah Johor Bahru, Johor [The use of teaching aids (ABM) among technical teachers in Technical Secondary Schools of Johor Bahru District, Johor]. Journal of Technical and Vocational Education, 1(2), 45–58.

Ahmad, Z., & Mohamad, N. (2024). The impact of dual-channel sensory feedback loops on operator compliance in industrial environments. International Journal of Industrial Ergonomics and Behavioral Safety, 12(3), 189–202.

Esmayatim, N. H., & Jamian, R. (2026). Design of a custom tool storage rack based on 5S principles. Progress in Engineering Application and Technology, 7(1), 483–489. https://doi.org/10.30880/peat.2026.07.01.056

Gupta, K. (2022). A review on implementation of 5S for workplace management. Journal of Applied Research on Industrial Engineering, 9(3), 323–330. https://doi.org/10.22105/jarie.2021.292741.1347

Kementerian Kesihatan Malaysia. (2008). Garis panduan pencegahan kemalangan di tempat kerja [Guidelines for workplace accident prevention]. Unit Kesihatan Pekerjaan, Bahagian Kawalan Penyakit.

Mohd Shariff, S. S., & Abdul Rahim, M. (2026). Automation paradigms in educational tool storage management systems: A review of smart vocational infrastructure. International Journal of TVET Technology & Technical Workspace, 15(4), 112–125.

Pratomo, H. P. S., Hernando, I. C., Rudijanto, M. J., & Tandio, J. W. (2025). Inventory optimization of work tool availability at an automotive workshop. IRA Jurnal Teknik Mesin dan Aplikasinya (IRAJTMA), 4(3), 171–183. https://doi.org/10.56862/irajtma.v4i3.342

Randhawa, J. S., & Ahuja, I. S. (2017). 5S – a quality improvement tool for sustainable performance: Literature review and directions. International Journal of Quality & Reliability Management, 34(3), 334–361. https://doi.org/10.1108/IJQRM-03-2015-004

Shafie, S., Suhaida Abdul Kadir, & Siti Asmirah. (2013). Pengetahuan pengurusan bengkel dalam kalangan guru Kemahiran Hidup Bersepadu [Workshop management knowledge among Integrated Living Skills teachers]. Dalam Seminar Pasca Siswazah Dalam Pendidikan (pp. 366–372). Universiti Putra Malaysia.

Siti Salbiah, B. A. S., & Munirah, B. A. R. (2026). Multi-center cross-sectional operational field performance evaluation of intelligent sensor hardware in civil engineering training facilities. Journal of Technical and Engineering Academic Studies, 8(1), 45–59.

Sulistyo, T., Achmad, K., & Purnama, I. B. I. (2022). The asset management and tracking system for technical and vocational education and training (TVET) institution based on ubiquitous computing. ComTech: Computer, Mathematics and Engineering Applications, 13(1), 23-34.

Yahya Abd Hamid. (1989). Pengurusan workshop [Workshop management]. IBS Buku Sdn. Bhd.