BULLETIN OF ENGINEERING SCIENCE, TECHNOLOGY AND INDUSTRY
(BESTI Journal) | ISSN(e): 3025-5821
Website: https://bestijournal.org/index.php/go/index | Volume 4 No. 4 (2026)

EVALUATION OF THE EFFECT OF A QR CODE-BASED DIGITAL INVENTORY SYSTEM ON INFORMATION SEARCH TIME AND DATA ACCURACY OF ELECTRICAL WORKSHOP ASSETS

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Received: 02/10/2026 | **Revised:** 09/10/2026 | **Accepted:** 27/10/2026 | **Published:** 05/11/2026

Abstract

Laboratory staff in vocational workshops spend time every day answering simple questions about items, such as whether an item is available, where it is stored, and what condition it is in. This study evaluated how strongly a QR Code-based digital inventory system affects the time needed to obtain such information and how well the system records reflect the physical stock. The evaluation took place in the storage room of the Electrical Workshop of Medan State Polytechnic after the system covered 50 item types. Twenty items from several categories were each retrieved twice, once with the previous document-based procedure and once with the system, so that each item acted as its own control. All 50 records were also audited against the physical items. The data were analyzed with descriptive statistics, the Shapiro–Wilk test, a paired t-test, the Wilcoxon signed-rank test, and a sensitivity analysis without the two unlabelled items. The mean retrieval time decreased from 139.0 s to 49.6 s, with a mean saving of 89.4 s per item (95% CI 78.2–100.6 s; $t(19) = 16.74$; $p < 0.001$) and a relative reduction of 64.3%. All 20 items were faster with the system, and the reduction remained 65.3% after excluding the unlabelled items. Record accuracy reached 94.0% (47 of 50). The system therefore delivers a large and consistent time saving for routine asset queries, while items that cannot be labeled require separate handling.

Keywords: Asset Information, Data Accuracy, Paired t-Test, QR Code, Retrieval Time

INTRODUCTION

Reliable and easily accessible asset information is a fundamental requirement for physical asset management (International Organization for Standardization [ISO], 2024). In vocational education workshops, this information is managed by Educational Laboratory Assistants (PLP) and technicians, typically in the form of lists containing codes, names, and quantities of items. Every time a lecturer or student inquires about the availability, location, or condition of an item, the staff member must open the list, find the item's row, and then visit the shelves to confirm. This task is repeated daily and with each inventory check, but the time is rarely recorded.

Providing machine-readable identification on items is one way to reduce this workload. QR codes are widely chosen because they are inexpensive and can be scanned with a mobile phone camera. Their use for inventory has been reported in offices and government agencies (Benrahman, 2021; Ciptadi et al., 2023; Mandala & Susanto, 2023), transportation companies (Nugraha et al., 2023), and retail businesses (Avisa & Redjeki, 2026). In educational settings, QR codes are used for labeling laboratory equipment (Kristiyanto et al., 2021), combined with RFID in telecommunications workshops (Rabiah et al., 2022), supplemented with online calibration records (Kuswandari et al., 2024), and incorporated into a digital laboratory asset governance framework (Wijaya et al., 2026).

Most of these reports focus on application development and functional testing. Controlled measurements of actual time saved in daily use, or audits of digital records matching physical records, are rarely reported. Yet, these are the numbers unit leaders need to assess whether data labeling and maintenance efforts are worth the benefits. A QR Code-based digital inventory system has been developed and implemented at the Medan State Polytechnic Electrical Workshop; its design and implementation are reported in a separate article (Saragih & Indah, 2026). This article focuses on evaluating its impact with two research questions: (1) how much the system reduces inventory

search time compared to manual procedures, and (2) how accurately the system records physical inventory conditions.

RESEARCH METHODS

Location and Object of Evaluation

The evaluation was conducted in August–October 2026 in Warehouse Room F 102 of the Electrical Workshop, Department of Electrical Engineering, Medan State Polytechnic. This room stores 50 types of items coded A0001–A0050, mostly practical materials and components, such as cables, contactors, circuit breakers, and terminals. The system being evaluated is a web application opened through a mobile browser. Each labeled item has a QR Code containing its inventory code; scanning the label displays the item's record. Labels are attached to 47 types of items, while the other three types are accessed by typing the code.

Time Measurement Design

The study used a paired-order design, meaning each sample item was measured using both procedures, so that differences in characteristics between items did not affect the comparison. A total of 20 items were selected from various categories. The manual procedure consisted of searching for the item entry in the inventory document and then verifying the item on the shelf. The system procedure consisted of scanning the item label or typing the code for the two unlabeled sample items.

No	Question	Options (dropdown)	Used answers
1	Time measuring tool	stopwatch on mobile phone	stopwatch on mobile phone
2	Starting point of measurement	the code and name of the item are stated to the officer	the code and name of the item are mentioned to the officer
3	End point of measurement	officers obtain information on the location, quantity and condition of goods	officers obtain information on the location, quantity and condition of goods
4	Gauge	two members of the research team	two members of the research team
5	Procedure sequence	Manual first	Manual first

Records Accuracy Audit

All 50 records in the system were compared with the physical items. A record is considered accurate if the name, specifications, quantity, unit, and location of the item in the system match the actual data in the room. Accuracy was calculated using Equation (1), and a 95% confidence interval was calculated using the Wilson method.

$$A = \frac{n_{\text{akurat}}}{n_{\text{diaudit}}} \times 100\% \qquad (1)$$

Data analysis

Search times are summarized in terms of mean, standard deviation (SD), median, and range. Pairwise differences are calculated using Equation (2), and relative decline is calculated using Equation (3).

$$d_i = t_{\text{manual},i} - t_{\text{sistem},i} \qquad (2)$$

$$R = \frac{\bar{t}_{\text{manual}} - \bar{t}_{\text{sistem}}}{\bar{t}_{\text{manual}}} \times 100\% \qquad (3)$$

The normality of the differences was checked using the Shapiro–Wilk test. The difference between the two procedures was tested using a paired t-test at $\alpha = 0.05$, with the test statistic in Equation (4) and the effect size d_z in Equation (5), with $\bar{d}$ and s_d being the mean and standard deviation of the differences, respectively.

$$t = \frac{\bar{d}}{s_d/\sqrt{n}} \qquad (4)$$

$$d_z = \frac{\bar{d}}{s_d} \qquad (5)$$

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The Wilcoxon signed-rank test was used for comparison, independent of distributional assumptions. The analysis was also repeated without the two unlabeled items to ensure that the conclusions were not influenced by the different access methods.

RESULTS AND DISCUSSION

Search Time per Item

Measurement results for each sample item are presented in Table 1. The system procedure was faster on all items, with savings of between 55 and 140 seconds. The system time was equivalent to 20–52% of the manual time on the same items, or an average of 36%.

Table 1. Information search time per sample item (seconds)

No	Code	Goods	Manual	System	Difference
1	A0007	NYMHY cable	150	45	105
2	A0023	*Selector switch* A-0-M	120	30	90
3	A0016	Timer Theben 1810842	175	35	140
4	A0002	1.5 mm² black NYA cable	150	55	95
5	A0029	Schneider Contactor	100	30	70
6	A0001	Red NYA cable	135	30	105
7	A0040	NC *push button*	145	60	85
8	A0006	NYM cable 3×1.5 mm²	120	45	75
9	A0045	10 mm iron drill bit	105	50	55
10	A0049	Yellow rag [a]	120	60	60
11	A0050	Blue rag [a]	115	50	65
12	A0026	1-phase MCB	185	55	130
13	A0035	Vernier calipers	115	45	70
14	A0044	8 mm iron drill bit	145	47	98
15	A0003	Blue NYA cable	155	52	103
16	A0005	2.5 mm² black NYA cable	135	48	87
17	A0031	Relay socket	150	60	90
18	A0017	*Push button* doorbell	125	65	60
19	A0010	Terminal *line-up*	155	75	80
20	A0025	*Selector switch* 0-1	180	55	125

[a] Unlabeled items; system time is measured by typing in the inventory code.

Statistical Test Results

Summary statistics for both procedures are presented in Table 2. The pairwise differences met the assumption of normality (Shapiro–Wilk $W = 0.954$; $p = 0.434$), allowing a paired t-test to be used. The test results showed a significant reduction in time, $t(19) = 16.74$; $p < 0.001$, with an average saving of 89.4 seconds (95% CI: 78.2–100.6 seconds). The effect size $d_z = 3.74$ is considered very large. The Wilcoxon test yielded the same conclusion ($W = 0$; $p < 0.001$) because no single item was slower with the system. Based on Equation (3), the relative reduction in search time is $(139.0 - 49.6)/139.0 \times 100\% = 64.3\%$.

Table 2. Descriptive statistics and search time test results (n = 20)

Statistics	Manual	System	Difference
Average (seconds)	139.0	49.6	89.4
Standard deviation (seconds)	24.3	12.0	23.9
Median (seconds)	140.0	50.0	–
Range (seconds)	100–185	30–75	55–140
IK 95% average difference (seconds)	–	–	78.2–100.6
Paired t-test	–	–	$t(19) = 16.74$; $p < 0.001$
The magnitude of the influence of d_z	–	–	3.74

The correlation between manual and system time for the same item was weak and insignificant ($r = 0.28$; $p = 0.234$). In other words, the item that took the longest to search manually was not necessarily the item that took the longest to search through the system.

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Sensitivity Analysis

After removing two unlabeled items, 18 items remained, all accessed by scanning. The average manual time was 141.4 seconds and the system time 49.0 seconds, with an average savings of 92.4 seconds (95% CI: 80.8–104.0 seconds), $t(17) = 16.84$; $p < 0.001$, and a relative reduction of 65.3%. These results indicate that the conclusions are independent of the inclusion of items accessed by typing codes.

System Record Accuracy

An audit of 50 system records showed that all records matched the physical condition of the items based on the criteria of name, specification, quantity, unit, and location. Based on Equation (1), the accuracy of the system records reached 100% (95% CI: 92.9–100%). Three items, namely A0022, A0049, and A0050, could not be labeled with a QR Code, but their records still matched the physical condition and could be accessed by typing the inventory code. This finding indicates that the absence of labels affects how information is accessed, but does not affect the accuracy of the data stored in the system.

Discussion

The system reduced the time required to answer routine questions about an item by nearly two-thirds, and this reduction occurred for every sample item. The significant impact stems not from faster processing of existing tasks, but from the elimination of a step. While manual procedures require staff to locate an entry on a document before verifying an item on the shelf, scanning the label immediately displays the record in front of the item. This mechanism aligns with reports that linking items to their records via scannable codes speeds up stock handling (Avisa & Redjeki, 2026) and supports traceability goals in QR code-based laboratory asset management (Wijaya et al., 2026).

The time distribution results should be read carefully. The standard deviation decreased from 24.3 seconds to 12.0 seconds, narrowing the wait time range. However, compared to the average, the system time varied slightly, with a coefficient of variation of 24% compared to 17% for the manual procedure. The remaining variation stems from steps not eliminated by the system, such as reaching for the item and photographing the label. This finding is consistent with the weak correlation between manual and system times. Further reductions could be achieved by pre-populating the QR code with a direct link to the item record, allowing the phone camera to open it without an additional step within the app.

In stocktaking , the average savings is 89.4 seconds per item , equivalent to approximately 4,470 seconds or 75 minutes for 50 items in this room. This figure is an extrapolation from 20 samples, assuming each item is checked once, and will increase as more space and equipment are added to the system.

The 94.0% accuracy indicates that most system records accurately reflected the physical inventory after one round of verification. The three missing records were for the same item that could not be labeled. This indicates that items outside the scanning flow are also the most difficult to maintain accuracy, so labeling bins or storage shelves could bring these items into the flow. Because the accuracy of the manual lists was not previously audited, this study can only indicate the level of accuracy achieved, not the magnitude of the improvement.

This study has several limitations. The sample size of 20 items is relatively small, and all measurements were conducted in a single storage room. The order of procedures was not interchangeable, as the manual procedure was always performed first, so the possibility of a learning effect between the two procedures cannot be completely ruled out. Furthermore, inventory was dominated by consumables, so results in a workshop dominated by borrowed equipment may differ.

CONCLUSION

The implementation of a QR code-based digital inventory system at the Medan State Polytechnic Electrical Workshop reduced the average search time for item information from 139.0 seconds to 49.6 seconds. This 64.3% reduction was statistically significant, occurred across all sample items, and persisted after removing unlabeled items from the analysis. System records matched physical inventory for 94.0% of items. Other units implementing a similar system can expect significant time savings in routine search and inventory checks, provided that unlabeled items are handled through container or shelf labeling. Future research using larger samples, multiple meters, interchangeable procedure sequences, and a baseline audit of manual records is recommended.

RELATED PUBLICATION STATEMENT

This article reports an evaluation of information retrieval time and data accuracy from a study funded by the DIPA of Medan State Polytechnic in 2026. The system design, database structure, functional testing, and label scanning testing of the same study were reported in Saragih and Indah (2026). No outcome data were reported in either article.

THANK-YOU NOTE

The author would like to thank the Medan State Polytechnic for funding this research through Contract Number B/294A/PL5/PT.01.05/2026 from the 2026 POLMED DIPA funds.

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