Exploring Workshop Management Systems in TVET: A Narrative Review

Mohd Lutfi Mohd Raffi[1], Mohd Azlan Mohammad Hussain[1*], Puteri Zarina Megat Khalid[2]

[1]Faculty of Technical and Vocational Education, Universiti Pendidikan Sultan Idris (UPSI), Malaysia

[2]Faculty of Languages and Communication, Universiti Pendidikan Sultan Idris (UPSI), Malaysia

***Corresponding Author**

DOI: https://dx.doi.org/10.47772/IJRISS.2025.901900007

Received: 07 July 2025; Accepted: 14 July 2025; Published: 21 July 2025

ABSTRACT

Technical and Vocational Education and Training (TVET) plays a pivotal role in cultivating a skilled workforce that meets evolving industry demands. Workshops, as central components of TVET delivery, require efficient and systematic management to ensure safety, resource optimization, and high-quality hands-on learning experiences. However, many TVET institutions continue to rely on manual or fragmented systems, leading to challenges such as poor asset tracking, maintenance delays, scheduling conflicts, and inconsistent documentation. This narrative review highlights five essential functional areas of Workshop Management Systems (WMS) utilized in TVET environments, including asset and inventory management, safety oversight, maintenance administration, workshop environment oversight, and documentation administration. Drawing on the Resource-Based View (RBV) theoretical framework, the study evaluates the strategic value of WMS features and demonstrates how they can function as valuable, rare, inimitable, and non-substitutable (VRIN) resources that contribute to sustainable competitive advantage. The findings highlight the need for context-specific, theory-driven digital systems to support institutional transformation and resilience. This review offers critical insights for institutional leaders, system developers, and policymakers aiming to modernise workshop operations, align with digitalisation agendas, and strengthen the future-readiness of TVET institutions.

Keywords: Workshop; Laboratory; Lean Management; Workshop management system; Resource-based view theory

INTRODUCTION

Technical and Vocational Education and Training (TVET) is necessary to build a skilled workforce meeting industry's changing needs and national development. TVET institutions feature laboratories or workshops as core components, in which hands-on, practical learning reinforces theoretical knowledge (Mohd Raffi et al., 2024). These practical settings are critical for equipping students with technical skills, real-world competencies, and workplace readiness. In the context of this paper, we will use the term *workshop* rather than *laboratory* to distinguish its focus on TVET programs, as people often associate the term laboratory with science subjects such as Physics, Chemistry, and Biology.

Workshop assets, stocks, and facilities represent a significant investment for TVET institutions, making their proper management essential. Effective management helps ensure that these resources are utilized efficiently and maintained sustainably. With systematic management, workshop managers can preserve equipment functionality, minimize wastage, and enhance the overall quality of hands-on training for students (Wang, 2022).

Although industries have widely adopted computerized systems to improve operational efficiency, many TVET institutions still rely on manual processes or fragmented tools to manage their workshop operations (Yahaya et al., 2024). This often results in issues such as resource mismanagement, scheduling conflicts, inadequate maintenance tracking, and inefficient documentation practices (Sulistyo et al., 2022). These

challenges highlight the urgent need for more integrated and systematic approaches to workshop management that support both administrative efficiency and the quality of practical instruction in TVET settings. Whether implemented manually or through digital systems, effective equipment and asset management is essential for maintaining productive learning environments and achieving institutional objectives (Ardian et al., 2020).

In industrial settings, systems such as the Computerized Asset Management System (CAMS) and Computerized Maintenance Management System (CMMS) are commonly employed to manage assets and maintenance operations effectively (Abdelrahman et al., 2020; Costa et al., 2024; Shaalan et al., 2022). The application of such systems can be implemented in the TVET context as it enables institutions to mirror industrial practices and manage workshop operations more professionally. This approach is also consistent with the Resource-Based View (RBV) theory, emphasizing the strategic value of internal resources in driving institutional performance.

To better understand how these systems contribute to institutional effectiveness, this paper adopts the RBV as its theoretical foundation. RBV posits that institutions can achieve sustainable competitive advantage by leveraging internal resources that are valuable, rare, inimitable, and non-substitutable (Barney, 1991). In the context of TVET, digital systems such as asset management systems (Fauzan et al., 2019; Oktavia & Wongso, 2015; Sulistyo et al., 2022) can be regarded as strategic internal resources. They strengthen operational capabilities and institutional readiness for digital transformation. In addition, RBV provides a useful lens through which to assess how the implementation of such systems enhances the overall efficiency, effectiveness, and competitiveness of educational organizations, including those in the TVET sector (Soliman & Karia, 2021; Vasudevan, 2021).

Despite the increasing trend of digitalization in education, limited scholarly attention has been given to the structured implementation of workshop management systems in TVET, particularly from the perspective of the RBV. There remains a significant gap in understanding the key functionalities of these systems as internal resources that contribute to institutional performance. Furthermore, the literature lacks detailed insights into the challenges and limitations associated with their adoption and integration. Most existing studies focus broadly on digital learning technologies or isolated aspects of workshop operations, without examining the role of holistic, integrated management systems specifically designed for vocational education. This paper aims to explore the role of workshop management systems as essential internal resources within TVET institutions, by identifying their core functions and examining how they can enhance institutional performance more effectively.

LITERATURE REVIEW

Workshop Management in TVET Institution

Workshop management is a critical component in Technical and Vocational Education and Training (TVET) institutions, especially in programs that emphasize hands-on learning and competency-based training. Efficient management of workshops ensures the availability of tools, safety of the environment, and readiness of facilities to support effective teaching and learning (Akhigbe et al., 2018; Bakri et al., 2022; Pangestu & Sukardi, 2019).

Best practice management that can be applied in workshop management is lean management, as suggested by Rafi, Jamaludin, et al., (2023). In line with Lean Management principles, TVET workshops are encouraged to minimize waste and optimize processes to improve value delivery. Originating from the Toyota Production System, Lean Management emphasizes the elimination of non-value-adding activities. This includes the continuous improvement of processes (Kaizen) and the involvement of all personnel in creating value for end users (Womack & Jones, 1996). The Lean Management practice in TVET institutions enables optimizing resource utilization, standardizing operational procedures, and adopting data-driven decision-making to enhance efficiency, reduce waste, and improve training outcomes (Ali, 2020; Rafi et al., 2021; Rafi, Wahab, et al., 2023).

In addition to Lean Management, 5S practices (Sort, Set in Order, Shine, Standardize, and Sustain) are also widely implemented in TVET workshops as mentioned in Setiawan & Ghani (2023); Rohmah (2024); Jiménez et al. (2015); Siahaan et al. (2020); and UNESCO, 2023). According to Hirano (1995):

- The Sort step involves removing unnecessary items from the workshop, ensuring that only essential tools and equipment remain.
- Set in Order refers to arranging items to ensure that they are easy to access and return, which minimizes time wasted in searching for tools.
- Shine emphasizes cleanliness and regular maintenance of the workspace to promote safety and equipment longevity.
- Standardize ensures that the first three steps are performed consistently through guidelines and procedures.
- Sustain focuses on developing a culture of discipline to maintain improvements over time.

The implementation of 5S in TVET workshops contributes to several positive outcomes. It promotes a culture of discipline and responsibility among students, reduces workplace hazards, improves productivity, and enhances the overall learning experience (Rafi, Wahab, et al., 2023). Therefore, the adoption of Lean Management and 5S practices in workshop management is a matter of operational efficiency and a pedagogical strategy that prepares students to function effectively in real-world industrial environments. As such, embedding these practices within TVET workshop systems contributes to both institutional excellence and graduate employability.

The Resource-Based View (RBV) in TVET Institutional Contexts

The Resource-Based View (RBV) theory, introduced by Barney (1991), posits that organizations can achieve and sustain competitive advantage through the strategic use of internal resources that are valuable, rare, inimitable, and non-substitutable (VRIN). While RBV has traditionally been applied in business and strategic management, it has increasingly gained relevance in educational settings. This is particularly true in analyzing how internal capabilities such as technological infrastructure, knowledge assets, and management systems contribute to institutional performance (Yaakub et al., 2021).

In the context of TVET, RBV provides a useful lens for analyzing how institutions can position digital tools such as workshop management systems as strategic resources (Vasudevan, 2021). These systems, when effectively implemented, can enhance operational efficiency, support administrative processes, and improve learning environments. This, in turn, becomes part of an institution's unique value proposition in preparing students for industry needs.

According to Gupta et al. (2018), information systems such as a workshop management system can be considered an internal firm resource as they are typically owned, managed, and customised by the institution itself. As such, they embody key characteristics of the RBV framework, particularly when the system is aligned with institutional goals, tailored to specific program requirements, and continually upgraded to meet evolving pedagogical and industry standards. For TVET institutions, this implies that workshop management systems must function as static tools and evolve with technological changes to sustain relevance and institutional agility.

Importantly, the RBV perspective complements Lean Management principles, which emphasize the elimination of waste, continuous improvement (Kaizen), and value creation for end users. Both RBV and Lean converge on the idea that internal processes and systems, when aligned with institutional strategy, can become critical enablers of competitive performance, as noted by Ismail & Zainuddin (2018) and Sriyadi et al. (2024) studies. For example, Lean-driven practices such as 5S (Sort, Set in Order, Shine, Standardize, and Sustain) enhance the operational visibility and efficiency of workshops. Meanwhile, RBV explains how such practices,

once embedded in digital systems, become unique capabilities that are challenging to replicate. This synergy strengthens the strategic case for implementing and refining workshop management systems in TVET settings.

Digitalization of Workshop Management in Industry and Education

Traditionally, many TVET institutions have relied on manual processes for managing assets, maintenance, safety, and documentation (Fauzan et al., 2019; Hassan et al., 2024; Lacasandile et al., 2023; Rosadi & Takim, 2023; Sulistyo et al., 2022). These include the use of logbooks, printed stock records, and manual maintenance scheduling, which often lead to data loss, human error, and inefficiencies. As the demands of industry evolve, there is a growing need to digitalize workshop management to align with current technological practices and improve administrative efficiency, as suggested by Yahaya et al. (2024).

In many industrial settings, digital management systems are now fundamental to daily operations. These systems enhance transparency, reduce human error, and align operational processes with best practices in quality management (Abdelrahman et al., 2020; Junaid & Jangda, 2020). Moreover, the digital transformation of workshop management in TVET institutions can be aligned with the United Nations Sustainable Development Goals (UN SDGs). It refers to a set of 17 global goals adopted in 2015 as part of the 2030 Agenda for Sustainable Development, aiming to end poverty, protect the planet, and ensure peace and prosperity for all by 2030 (Fowdur & Radhakeesoon, 2025). Table 1 presents the specific goals that align with the digitalization of workshop management practices in TVET settings. Therefore, modernizing workshop management is an operational necessity and a strategic move toward improving institutional quality, relevance, and sustainability.

Table 1 TVET workshop management digitalization in the context of SDGs (adapted from United Nation, 2025)

SDG	Goals descriptions
Goal 4: Quality Education	Ensuring effective infrastructure and management for practical training.
Goal 9: Industry, Innovation and Infrastructure	Promoting the adoption of innovative digital systems within the education sector.
Goal 12: Responsible Consumption and Production	Enhancing inventory tracking, reducing waste, and ensuring the efficient use of workshop resources.

METHODOLOGY

This study adopts a narrative review approach to explore the application of Workshop Management Systems (WMS) within the context of Technical and Vocational Education and Training (TVET). A narrative review, also known as a traditional or expert review, is a type of literature review that provides a comprehensive overview of a specific topic or theme (Henry et al., 2018). In the context of this paper, the four-step method to write a narrative review, as derived from the study by Demiris et al. (2019), is applied.

Step 1: Literature Research

To gather relevant literature, a search was conducted using two academic databases: Scopus and Google Scholar. Scopus was selected for its comprehensive coverage of peer-reviewed and high-impact journals, ensuring the inclusion of credible and high-quality sources (Baas et al., 2020). Conversely, Google Scholar was selected for its broad accessibility and ability to capture grey literature and a wider range of academic materials relevant to the topic (Haddaway et al., 2015).

Step 2: Identification of Keywords

The primary aim of this narrative review is to identify and describe the key functionalities of workshop management systems used in TVET institutions. This review does not focus on a specific country or institution but rather synthesizes global perspectives to generate a broader understanding of the subject. The search included peer-reviewed journal articles and conference proceedings published between 2015 and 2025. The primary keywords used to identify suitable and relevant studies are "Workshop Management System,"

"Laboratory Management System," "Technical and Vocational Education and Training," "TVET," "Laboratory Information Management System," and "Laboratory Management System." These terms were used both independently and alongside related keywords and synonyms to broaden the search scope. Variations and combinations included phrases such as "workshop management system element," "functions of workshop management systems," and "key components of workshop management systems." This approach aligns with the recommendation by Demiris et al. (2019), who emphasized the significance of using multiple keyword combinations to identify literature relevant to the objectives of the review.

Step 3: Review Abstracts and Articles

Following the completion of the search process and the removal of duplicate entries, the remaining articles were screened through a two-stage process. First, titles and abstracts were reviewed to determine their relevance to the review objectives. Articles that passed this initial screening were then subjected to full-text analysis to assess their alignment with the scope and aim of the study. In narrative reviews, it is not necessary to include every available article on a topic. Instead, emphasis is placed on selecting studies that offer depth and relevance to the research question (Demiris et al., 2019). The inclusion criteria for this review were: (i) publications discussing workshop or laboratory management systems within educational or TVET contexts; (ii) studies addressing system functionalities; and (iii) articles written in English or Malay. Studies were excluded if they focused solely on technical specifications without relevance to TVET or educational settings.

Step 4: Document Results

The selected literature was then thematically analyzed to identify patterns related to system functionalities. Sub-themes emerged to elaborate on the specific functions embedded within workshop management systems. This analysis was guided by the Resource-Based View (RBV) theoretical framework, with particular emphasis on how these systems operate as internal resources that enhance institutional capability, efficiency, and adaptability. Finally, the findings were organized and presented in a table to enhance clarity and facilitate a better visual understanding of the identified system functions.

RESULTS & DISCUSSIONS

The narrative synthesis of the selected literature reveals a set of core functionalities that characterize Workshop Management Systems (WMS) in Technical and Vocational Education and Training (TVET) institutions. These systems are designed to support both administrative efficiency and instructional effectiveness by managing key aspects of workshop operations. From the reviewed studies, five main functionalities were identified, which are grouped into thematic categories in Table 2. The five themes function also aligned with Mohd Raffi et al. (2024), emphasizing there are five elements in workshop management system: 1) asset and stock management; 2) safety management; 3) maintenance management; 4) workshop environment management; and 5) workshop documentation management.

Table 2 Key Functionalities of Workshop Management Systems (WMS) in TVET

Theme	Sub-theme	Functionality	References
Asset and stock management	Record	Tracking the availability of the equipment using Laboratory Information System (LIS)	Lacasandile et al. (2023)
		Recording stock of equipment and material supplies using SIMPAL	Rosadi & Takim (2023)
		Recording stock of equipment and material supplies using AMIS	Setiawan et al. (2019)
		Tracking location and asset availability in real time	Junaid & Jangda (2020); Oktavia & Wongso (2015); Sulistyo et al. (2022)
		Monitoring assets using MySPATA	Nasir et al. (2022)
	Borrowing & Returning	Borrowing method using the Laboratory Inventory System	Lacasandile et al. (2023)
		Asset borrowing and returning using QR Code	Sulistyo et al. (2022)

		Processing of borrowing and returning equipment using SIMPAL	Rosadi & Takim (2023)
		Borrowing method using the Asset Management System	Oktavia & Wongso (2015)
	QR Code generator	Generating a QR Code for asset identification and the borrowing process	Halimatun Sa'adiah Harith et al. (2020); Sulistyo et al. (2022)
	Disposal	Disposing of assets that cannot be repaired or are outdated using MySPATA	Nasir et al. (2022)
Safety management	First aid kit	Inspecting the record for the first aid kit using the Occupational Health and Safety Management System (SMK3)	Windasari et al. (2019)
	Fire extinguisher	Inspecting the record for the fire extinguisher using the Occupational Health and Safety Management System (SMK3)	Windasari et al. (2019)
	Incident report	Reporting an incident using the Occupational Health and Safety Management System (SMK3)	Windasari et al. (2019)
		Risk assessment by reporting incidents using e-HIRARC tools	Hassan et al. (2024)
		Reporting a safety incident in LIMS	Junaid & Jangda (2020)
	Safety information	Safety information via e-HIRARC for hazard identification and risk control.	Hassan et al. (2024)
Maintenance management	Maintenance request	Maintenance request using the Asset Management System	Oktavia & Wongso (2015)
		Equipment management using LIMS	Junaid & Jangda (2020)
		Asset maintenance using MySPATA	Nasir et al. (2022)
		Maintaining assets using the Asset Management Information System	Fauzan et al. (2019)
	Maintenance schedule	Maintenance scheduling using the Asset Management System	Oktavia & Wongso (2015)
Workshop environment management	Asset facilities	Maintenance request for workshop facilities	Oktavia & Wongso (2015)
		Laboratory/workshop management and maintenance	Junaid & Jangda (2020)
Workshop documentation management	Booking	Workshop booking using TMRCODE	Halimatun Sa'adiah Harith et al. (2020)
		Booking system using LIMS	Junaid & Jangda (2020)
	Asset management report	The Asset Management system can generate an asset management report on time since all the data is already integrated into the database	Oktavia & Wongso (2015)
		Generating asset data report, report asset depreciation, asset type report, asset location report, and asset provider report using AMIS (asset management information system)	Setiawan et al. (2019)

The findings indicate that each sub-theme represents a specific functionality within the WMS, reflecting the system's alignment with the operational priorities of TVET institutions. In total, 13 sub-themes were identified and systematically categorised under the five core functional areas mentioned in Table 2. This thematic structure confirms the comprehensiveness of WMS implementations and illustrates how digital tools are tailored to meet practical institutional needs.

Among these, asset and stock management function emerged as the most dominant theme, suggesting that WMS solutions in TVET settings are primarily geared towards managing physical resources such as tools, equipment, and consumables. This emphasis is aligned with the hands-on nature of TVET programs, where the

availability, usability, and traceability of assets are crucial for effective training delivery (Sulistyo et al., 2022). The prevalence of this function highlights the role of digital systems in improving inventory accuracy, reducing resource wastage, and supporting efficient asset utilisation as suggested in the lean management strategy (Rafi, Jamaludin, et al., 2023).

The findings also align with the Resource-Based View (RBV) theory, which conceptualizes internal systems as strategic resources that enhance institutional capability, operational efficiency, and adaptability (Wernerfelt, 1984). To improve clarity and provide a structured synthesis of the results, the implementation of WMS in TVET institutions is organized and presented in Table 3 based on the VRIN criteria. According to RBV, for a resource to generate a sustainable competitive advantage, it must satisfy four key criteria, collectively referred to as VRIN: 1) valuable, 2) rare, 3) inimitable, and 4) non-substitutable (Barney, 1991).

Table 3 WMS functionalities mapping to VRIN criteria (adapted from Barney, 1991)

VRIN criteria	Explanation	The implementation of WMS in TVET institutions
Valuable	Contributes directly to improving institutional operations and student readiness.	A well-implemented Workshop Management System (WMS) helps improve training delivery in TVET by making asset tracking, borrowing processes, safety checks, and maintenance schedules more efficient. These functions reduce operational problems, make better use of resources, and help administrators and instructors make informed decisions.
Rare	Not commonly found in other institutions in the same integrated and customised form.	Some advanced features, such as real-time asset tracking, integrated safety reporting, and predictive maintenance, are still not widely used in many TVET institutions, especially in developing countries. Institutions that adopt these features have better control and can respond more effectively than others.
Inimitable	Difficult to replicate due to internal processes, embedded practices, and system customisation.	WMS that is deeply integrated into an institution's specific workflows, such as customised safety procedures, equipment handling protocols, or instructional scheduling, develops unique institutional knowledge over time. This embedded integration makes the system highly context-specific and difficult to imitate or transfer elsewhere without significant adaptation.
Non-substitutable	Cannot be replaced by another tool or method offering equivalent benefits.	A complete WMS that combines asset, safety, documentation, and scheduling functions into one platform offers strategic advantages. Unlike using separate systems, this integration supports smooth daily operations and also helps the institution move forward in its digital transformation.

When evaluated through the VRIN lens, the implementation of a tailored Workshop Management System (WMS) in Technical and Vocational Education and Training (TVET) institutions can be considered a strategic internal resource. It enhances institutional resilience, improves training quality, and supports long-term competitive positioning within the vocational education landscape. By adopting a narrative review method, this study offers a comprehensive overview of how WMS is currently implemented in TVET settings, providing a foundational reference for the future development of such systems.

CONCLUSIONS

This study examined the key functionalities of Workshop Management Systems (WMS) within Technical and Vocational Education and Training (TVET) institutions and explored their alignment with the Resource-Based View (RBV) theoretical framework. Through a narrative synthesis of selected literature, five core functional areas were identified: 1) asset and stock management, 2) safety management, 3) maintenance management, 4) workshop environment management, and 5) workshop documentation management. Each core function is supported by 13 specific subfunctions. Among these, asset and stock management emerged as the most prominent. This highlights the centrality of resource control and inventory efficiency in workshop-based TVET operations.

The analysis demonstrates that WMS functions do more than support administrative tasks. They serve as strategic internal resources that can enhance institutional capability, improve operational efficiency, and drive innovation in teaching and learning practices. When assessed through the VRIN lens, several WMS features were deemed valuable, rare, inimitable, and non-substitutable. These characteristics qualify them as sources of sustainable competitive advantage for TVET institutions.

Limitation of the study

Although the narrative approach enables flexibility and thematic depth, several limitations must be acknowledged. Firstly, the study lacks empirical validation, as it relies exclusively on secondary sources without incorporating primary data collection methods such as interviews, surveys, or institutional case studies. Consequently, the findings may not fully reflect the practical challenges or user experiences associated with WMS implementation in real-world TVET environments. Secondly, the diversity of TVET institutions across different countries and regions presents generalisation constraints. Differences in institutional funding, digital infrastructure, staff capacity, and policy contexts may affect the applicability of the findings across settings. Thirdly, the Resource-Based View (RBV) offers a strategic perspective to assess the internal value of WMS. However, it does not fully account for external influences such as government regulations, socio-cultural factors, or industry engagement factors, which also significantly shape the adoption and success of such systems, as suggested by Bakri et al. (2022).

RECOMMENDATION

Based on the identified limitations, several recommendations are proposed for future research. First, empirical case studies should be conducted to examine real-world WMS implementation across selected TVET institutions. This would yield more profound insights into system usability, integration challenges, and stakeholder perceptions. Second, future researchers are encouraged to adopt a Design and Development Research (DDR) approach. It utilises multi-method strategies and expert consensus techniques to guide the system development process in a more structured and evidence-based manner, as suggested by Mohd Ridhuan & Nurul Rabihah (2024). Third, comparative studies across institutions or countries can help identify best practices as well as enablers or barriers to effective WMS implementation in different contexts. Fourth, future work could explore the integration of Industry 4.0 technologies, such as the Internet of Things (IoT) for real-time asset tracking, Artificial Intelligence (AI) for predictive maintenance, and blockchain for secure audit trails. Finally, policy-oriented research is needed to ensure that WMS implementation is aligned with national TVET policies and digitalisation agendas, thus supporting systemic reforms at the institutional and national levels.

Ultimately, the integration of digital systems, such as WMS, represents a technological upgrade and a strategic transformation that strengthens institutional performance and future-readiness. As TVET continues to evolve to meet industry demands, the adoption of context-specific and theory-driven systems such as WMS will be essential in ensuring that vocational education remains relevant, efficient, and resilient.

REFERENCES

1. Abdelrahman, O., Abdalaal, A., & Shukri, M. I. (2020). Implementation of Computerized Maintenance Management System in Maintenance Workshop. International Journal of Engineering Applied Sciences and Technology, 4, 100–103. http://www.ijeast.com
2. Akhigbe, A. E., Ejiofor, V. E., Olawepo, B. B., & Ihuoma, S. (2018). An Assessment of Workshop Facilities Management Practices in Technical Colleges of Edo States. Journal of Arts, Management Science and Technology, 5(2), 54–64.
3. Ali, M. M. (2020). Kajian Tahap Kesediaan Praktis Pengurusan Lean Dalam Pengajian Separuh Masa Di kalangan Pensyarah Tvet. Journal on Technical and Vocational Education (JTVE), 5(2), 32–38. http://upikpolimas.edu.my/ojs/32
4. Ardian, A., Munadi, S., & Jarwopuspito. (2020). Management analysis of workshop equipment and laboratory in vocational education. Journal of Physics: Conference Series, 1446(1). https://doi.org/10.1088/1742-6596/1446/1/012030

5. Baas, J., Schotten, M., Plume, A., Côté, G., & Karimi, R. (2020). Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. Quantitative Science Studies, 1(1), 377–386. https://doi.org/10.1162/qss_a_00019
6. Bakri, A., Alkbir, M., Awang, N., Mohd Tohid, M. Z. W., S.J., F., Ismail, M., Ahmad, A. N. A., & Zakaria, I. (2022). A Review on Critical Success Factors for Maintenance Management of Laboratory and Workshop Facilities in TVET Institution. 1–11. https://doi.org/10.1007/978-3-031-01488-8_1
7. Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. Journal of Management, 17(1), 99–120.
8. Costa, J., Torres, L., & Borges, M. (2024). From Preventive Maintenance to Predictive Analytics: Insights into the Evolution of AMS for Physical Assets. In A. D. Ball, H. Ouyang, J. K. Sinha, & Z. Wang (Eds.), Proceedings of the UNIfied Conference of DAMAS, IncoME and TEPEN Conferences (UNIfied 2023) (pp. 637–649). Springer Nature Switzerland.
9. Demiris, G., Oliver, D. P., & Washington, K. T. (2019). Chapter 3 - Defining and Analyzing the Problem. In G. Demiris, D. P. Oliver, & K. T. Washington (Eds.), Behavioral Intervention Research in Hospice and Palliative Care (pp. 27–39). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-814449-7.00003-X
10. Fauzan, R., Pamungkas, V. Y., & Wibawa, J. C. (2019). Information System for Asset Management. IOP Conference Series: Materials Science and Engineering, 662(2). https://doi.org/10.1088/1757-899X/662/2/022020
11. Fowdur, T. P., & Radhakeesoon, A. (2025). An Educational Framework for the Disruptive Technologies and their Integration in the UN SDGs Curriculum. Journal of Educational Technology Development and Exchange, 18(1), 215–239. https://doi.org/10.18785/jetde.1801.12
12. Haddaway, N. R., Collins, A. M., Coughlin, D., & Kirk, S. (2015). The role of google scholar in evidence reviews and its applicability to grey literature searching. PLoS ONE, 10(9). https://doi.org/10.1371/journal.pone.0138237
13. Halimatun Sa'adiah Harith, Mohd Fadzwan Junaidi, Romy Abd Kadir, Azhar Hashim, & Ruba'ie Said. (2020). Penggunaan Teknologi Mirroring dan QR Code (TMRCODE) di dalam Bengkel Reka Bentuk dan Teknologi (RBT). International Innovation Competition (INNOCOM) 2020, 386–390.
14. Hassan, M., Aziz, H. A., & Rahim, M. Z. (2024). e-HIRARC Tool for Brick Laboratory in Civil Engineering Department at TVET (Technical and Vocational Education Training) Campus. Lecture Notes in Mechanical Engineering, 425–436. https://doi.org/10.1007/978-981-99-6890-9_34
15. Henry, B. M., Skinningsrud, B., Vikse, J., Pękala, P. A., Walocha, J. A., Loukas, M., Tubbs, R. S., & Tomaszewski, K. A. (2018). Systematic reviews versus narrative reviews in clinical anatomy: Methodological approaches in the era of evidence-based anatomy. Clinical Anatomy, 31(3), 364–367. https://doi.org/10.1002/ca.23042
16. Hiroyuki Hirano. (1995). 5 Pillars of the Visual Workplace: The Sourcebook for 5S Implementation (1st ed.). Productivity Press.
17. Ismail, A., & Zainuddin, Y. (2018). An Empirical Study on Lean Management and HRM Practices in Relation towards Operational Performance. TURKISH ONLINE JOURNAL OF DESIGN ART AND COMMUNICATION, 8(SEPT), 1167–1175. https://doi.org/10.7456/1080sse/158
18. Jiménez, M., Romero, L., Domínguez, M., & Espinosa, M. del M. (2015). 5S methodology implementation in the laboratories of an industrial engineering university school. Safety Science, 78, 163–172. https://doi.org/10.1016/j.ssci.2015.04.022
19. Junaid, S., & Jangda, Z. (2020). Successful deployment of a laboratory information management system LIMs; striding towards modern, paperless labs. International Petroleum Technology Conference 2020, IPTC 2020. https://doi.org/10.2523/iptc-19656-ms
20. Lacasandile, A. D., Alejandro, D. C. B., Canivel, A. B. R., Era, A. D., & Gulmatico, M. R. R. D. (2023). Modernization of Resource Borrowing: The Inception of the National University Allied Health Laboratory Inventory System. 2023 IEEE 15th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management, HNICEM 2023. https://doi.org/10.1109/HNICEM60674.2023.10589223

21. Mohd Raffi, M. L., Mohammad Hussain, M. A., & Zulkifli, R. M. (2024). Key Elements of Workshop Management System for Vocational College in Malaysia. International Journal of Academic Research in Progressive Education and Development, 13(1). https://doi.org/10.6007/ijarped/v13-i1/20880
22. Mohd Ridhuan Mohd Jamil, & Nurul Rabihah Mat Noh. (2024). Penyelidikan Reka Bentuk dan Pembangunan: Teori dan Aplikasi (1st ed.). Qaisar Prestige Resources.
23. Nasir, A. A. I. M., Azri, S., & Ujang, U. (2022). Asset Management in Malaysia: Current Status. IOP Conference Series: Earth and Environmental Science, 1064(1). https://doi.org/10.1088/1755-1315/1064/1/012035
24. Oktavia, T., & Wongso, A. (2015). Asset Management System for Computer Laboratory. Journal of Theoretical and Applied Information Technology, 10(1). www.jatit.org
25. Pangestu, F., & Sukardi, S. (2019). Evaluation of the implementation of workshop and laboratory management on vocational high school. Jurnal Pendidikan Vokasi, 9(2), 172–184. https://doi.org/10.21831/jpv.v9i2.25991
26. Rafi, S. M., Jamaludin, M. F., & Ahmad, M. F. (2023). Lean Management Practice for Technical and Vocational Education and Training (TVET) Institutions in Malaysia. 2023 International Conference on University Teaching and Learning, InCULT 2023. https://doi.org/10.1109/InCULT59088.2023.10482530
27. Rafi, S. M., Raju, V., Imran Ibrahim Alasan, & Maswichian, N. (2021). Experiencing Lean soft lean factors in Higher Education. International Journal of Mechanical Engineering, 6(3).
28. Rafi, S. M., Wahab, T. M. A. A., & Ahmad, M. F. (2023). Leadership with Standardized Practise in TVET Institutions: A Quality System Improvement. Open Journal of Social Sciences, 11(05), 145–161. https://doi.org/10.4236/jss.2023.115012
29. Rohmah, I. Y. (2024). Implementation of 5S Methodology in Educational Institutions: Benefits, Challenges, and Strategies for Sustainability Enhancement. Kalam Cendekia: Jurnal Ilmiah Kependidikan, 12(2), 1–10.
30. Rosadi, I., & Takim. (2023). Pembuatan Sistem Informasi Pengelolaan Laboratorium (SIMPAL) Menggunakan Borland Delphi 7.0. In Jurnal Pengelolaan Laboratorium Pendidikan (Vol. 5, Issue 1).
31. Setiawan, A., & Ghani, S. R. W. (2023). Analisis Implementasi Budaya 5S dalam Penataan Laboratorium Teknik Industri Universitas Hasyim Asy'ari. Jurnal Penelitian Bidang Inovasi & Pengelolaan Industri, 2(2), 9–16. https://doi.org/10.33752/invantri.v2i2.3738
32. Setiawan, R., Kurniadi, D., Aulawi, H., & Kurniawati, R. (2019). Asset management information system for higher education. Journal of Physics: Conference Series, 1402(2). https://doi.org/10.1088/1742-6596/1402/2/022083
33. Shaalan, A. A., Morris, A., & Baglee, D. (2022). The development of CMMS platform incorporating condition monitoring tools in the advances of Industry 4.0. 18th International Conference on Condition Monitoring and Asset Management, CM 2022, 436–448. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85145874234&partnerID=40&md5=4d233247db1ba35ef2d63363ad3a741e
34. Siahaan, F. S., Purba, J., Buwono, A., Ratih, R., & Refendi, H. (2020). The monozukuri concept as the right 5S implementation tool in Jakarta Vocational High Schools. Journal of Physics: Conference Series, 1469(1). https://doi.org/10.1088/1742-6596/1469/1/012129
35. Soliman, M., & Karia, N. (2021). Role of Resource-based View in Predicting ERP Perceived Value: Higher Education Perceptions. Journal of Technology Management and Business, 8(1), 10–19. https://doi.org/10.30880/jtmb.2021.08.01.002
36. Sriyadi, Ratnawati, T., & Andjarwati, T. (2024). Modern management model for KAREB Bojonegoro cooperative: Integration of ABM, lean six sigma, and RBV and TPB approaches. Edelweiss Applied Science and Technology, 8(6), 3402–3420. https://doi.org/10.55214/25768484.v8i6.2720
37. 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. https://doi.org/10.21512/comtech.v13i1.7342

38. UNESCO. (2023). Promising Practices in TVET: Shaanxi, China TVET Industry Centre. https://unevoc.unesco.org/pub/promising_practices_shaanxi_china_tvet_industry_centre.pdf
39. United Nations. (2025, July 13). The 17 Sustainable Development Goals. Https://Sdgs.Un.Org/Goals.
40. Vasudevan, H. (2021). Resource-Based View Theory Application on the Educational Service Quality. International Journal of Engineering Applied Sciences and Technology, 6(6), 174–186. https://doi.org/10.33564/IJEAST.2021.v06i06.026
41. Wang, F. (2022). Research on Intelligent Management of Laboratory Information Technology. Procedia Computer Science, 208, 184–189. https://doi.org/10.1016/j.procs.2022.10.027
42. Wernerfelt, B. (1984). A Resource-Based View of the Firm. In Strategic Management Journal (Vol. 5, Issue 2).
43. Windasari, I. P., Purba, K., Eridani, D., Septiana, R., & Mahachandra, M. (2019). Application Development of Inspection of Fire Protection Equipment, First Aid Kit and Incident Reporting Case Study. The 7th International Conference on Public Health, 184–187. https://doi.org/10.26911/the7thicph-FP.02.11
44. Womack, J., & Jones, D. (1996). Lean Thinking : Banish Waste and Create Wealth in Your Corporation. In Journal of the Operational Research Society (Vol. 48). https://doi.org/10.1038/sj.jors.2600967
45. Yaakub, M. H., Aziz, A. S. A., Nor, M. F. A. H., & Mohamed, Z. A. (2021). Exploring the role of technology infrastructure capability and intrapreneurship to influence higher education institutions' performance. Journal of Physics: Conference Series, 1793(1). https://doi.org/10.1088/1742-6596/1793/1/012012
46. Yahaya, W. A. J. W., Restu, R., & Sriadhi, S. (2024). Multimedia-based Information System for Technology and Vocational Education Laboratory. Profesional de La Informacion, 33(1). https://doi.org/10.3145/epi.2024.0012