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Development of a Framework for Lean Education Implementation in Vocational High Schools

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Abstract— ***Lean, which aims to eliminate waste, has been applied to manufacturing and non-manufacturing operations. Some studies reported that lean applications improve operations in universities and high schools. This study aims to develop a framework for implementing Lean Education for vocational high schools (SMK). This research is motivated by various forms of waste in SMK operations, such as long waiting times. A combination of an exploratory qualitative approach, literature review, and expert validation is utilized to construct a context-specific framework. The proposed framework consists of three main stages: pre-implementation, implementation, and post-implementation, each comprising key activities such as waste identification, staff training, process mapping, lean strategy execution, and continuous improvement. This framework is expected to support SMK in minimizing waste and aligning vocational education more closely with industry needs, thereby enhancing the quality of its graduates.***

Index Terms—About; **Lean Education, vocational schools, waste reduction, practical learning, implementation framework**

I. INTRODUCTION

Vocational High Schools (SMK) are formal educational institutions that strategically prepare graduates to be competent and ready to enter the workforce according to industry needs. However, in practice, vocational learning at SMKs, particularly in hands-on activities like using lathe machines, often encounter various forms of waste that negatively affect the effectiveness and efficiency of the teaching and learning process. Types of waste commonly found in SMKs include long waiting times due to limited access to practical equipment (waiting), excessive use of practice materials (excess inventory), work results that do not meet industrial specifications (defects), and time lost during equipment setup processes (setup time). These issues hinder students from achieving the required competencies, increasing teachers' workloads, and creating a disconnect between the educational process and industry demands. The concept of Lean Thinking, which originated in the manufacturing sector, has been widely adopted in various service sectors, including education. Lean Education aims to identify and eliminate non-value-added activities in educational processes to create a more efficient and sustainable learning system [6]. However, most lean applications in education have focused on higher education and general senior high schools, while implementation at the vocational high school level—especially in hands-on vocational training—remains very limited. Several previous studies have proposed frameworks for implementing lean education, such as the dynamic model by Anvari et al (2011), the application of lean principles in business schools by Emiliani (2004), and the integration of Value Stream Mapping (VSM) in educational laboratories by Manos & Almeida (2024). Nevertheless, no framework has been specifically designed and validated for the context of secondary-level vocational education, such as SMKs in Indonesia. Based on this background, this study aims to develop a framework for implementing lean education that can help SMKs design and manage practical learning activities more efficiently and effectively. By integrating findings from literature reviews and validation by vocational education experts, this framework is expected to serve as a

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practical reference for schools to minimize waste and improve the quality of vocational education delivery.

II. LITERATURE REVIEW

Waste is any activity, process, or resource that fails to contribute value to a production system and should therefore be minimized or eliminated [9]. Research by Mulyana et al (2022) proposes 8 waste categories of 46 waste in the Higher Education setting (Table 1).

Table 1 Waste in Higher Education Institution [9]

No.	Category of Waste	Form of Waste in Higher Education Institution
1	Defects	The lecturer failed to find the document.
		Going to the wrong classroom.
		The lecturer did not inform of the absence/cancellation of the class on the due class schedule.
		Lecturers change the lecture schedule.
		Lecturers make mistakes when inputting grades in the academic information system.
		The lecturer re-examines students.
		The lecturer encountered inaccessible documents.
		The lecturer has encountered teaching material media that cannot be opened.
		Human error in typing
		Lecturers have made mistakes in typing learning preparation and teaching materials.
		The lecturer found the projector connecting cable unusable.
2	Overproduction	Lecturers have experienced a shortage of exam scripts.
		Lecturers print documents/exam questions/journals/handouts in excess.
		The teaching load every semester is excessive.
		Lecturers add lecture hours outside the predetermined schedule.
		There is excessive dissemination of information/announcements.
		There are too many lecturers in the department.
		Lecturers do administrative tasks outside of working hours
3	Waiting	Lecturers reply to messages/questions from students for quite a long time.
		The delay of the lecturer in collecting reports from a predetermined time.
		Lecturer delay in attending meetings.
		Lecturers wait for class when the class to change.
		Repair of campus facilities has taken a long time.
		The lecturer is waiting for the meeting to determine the results of the teaching task.
		Lecturers wait for students to attend lectures.
		The lecturer waits for students to collect answers to the exam.
4	Non-Utilized Talent	Students are late in submitting assignments.
		Lecturers get jobs/assignments that are not in accordance with their scientific field.
		Lecturers do not conduct research every semester.
		Lecturers do not do community service every semester.
5	Transportation	Lecturers make mistakes in sending documents/files between work units.
6	Inventory	The lecturer keeps the email on the draft.
		The lecturer keeps the previous year's exam questions.

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6	Inventory	Lecturers keep a large number of documents (for example: teaching materials/handouts/exam questions/journals). Lecturers keep large amounts of Office Stationery. Class facilities that are owned are not used during operating hours.
7	Motion	The distance between the classroom and the office/work space is quite far. The lecturer workspace is always in an untidy condition. Lecturers look for documents/files/journals for a long time.
8	Extra Processing	Lecturers input student scores more than once in different systems. Receiving information through more than one information channel (WhatsApp, email, hard copy, etc.). The posting of the same information/announcement repeatedly. The lecturer checks/corrects the same files (exam answers, theses, correspondence, etc.) repeatedly. The lecturer checks the teaching material repeatedly. The lecturer teaches the same material over and over. Lecturers attend/make meetings repeatedly with the same discussion.

A summary of literature review of various studies on lean education can be seen in Table 2.

Table 2 Studies on Lean Education Implementation

Author	**Journal Title**	**Tools**	**Research Object**	**Lean Implementation Framework**
[8]	Towards Lean Teaching: Non-Value-Added Issues in Education	Lean Thinking, Value Stream Mapping (VSM), Lean Tools	Leaning Education at University Level	Planning, Implementation, Evaluation, Follow-up
[4]	Lean Education Analysis to Minimize Waste in High School Chemistry Learning	VSM, Failure Mode and Effects Analysis (FMEA), Fishbone Diagram	Leaning Education in Chemistry Learning at High School	Problem identification (Define), Mapping current state using VSM, collecting data and calculating lead time and cycle time (Measure), Waste analysis (Analyze), Designing Future State VSM (Improve), Monitoring implementation results (Control)
[11]	Improving Teaching and Learning Process by Applying Lean Thinking	Lean Thinking, 5S Methodology, Visual Management	Lean Education in Engineering Laboratory at the University of Novi Sad, Serbia	Identification of value-added and non-value-added activities, Current state mapping using VSM, Waste identification and

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Author	Journal Title	Tools	Research Object	Lean Implementation Framework
				analysis, Designing Future State VSM, Evaluation
[10]	The Application of Lean Management Method in Optimizing Administrative Efficiency in Schools	Lean Management (5S, VSM, Kaizen)	Lean Management in School of Administration in Indonesia	Identification of administrative processes, Current process mapping using VSM, Waste identification, Root cause analysis, designing improvement proposals, Change implementation, Evaluation, and continuous improvement (Kaizen)
[5]	Improving Business School Course by Applying Lean Principles and Practices	Lean Principles (VSM, Kaizen, Voice of Customer, PDCA, Customer Value Model)	Lean Education in Business Schools	Waste identification, VSM implementation, Continuous improvement through PDCA, Monitoring and evaluation of student satisfaction
[7]	Quality Assessment of Laboratory Activities in Professional Education Institutions Based on Lean Thinking	Learn Thinking (VSM, KPI)	Lean Education in Laboratory of Educational Institutions	Planning and formation of functional teams, Process mapping using VSM, Implementation of improvement strategies, Lean culture adoption
[2]	A Proposed Dynamic Model for a Lean Roadmap	Lean (VSM, PDCA, Lean Self-Assessment Tool)	Lean Framework in Manufacturing Industry	Preparation, Design, Implementation
[6]	A New Method in Education: Lean	Lean Education (VSM, 5S, Kaizen, Root Cause Analysis, Visual Management)	Lean Education in Technical Higher Education in Ghana	Value identification, VSM mapping, Creating flow, Student needs analysis, Continuous improvement (Kaizen)
[3]	Service Value Stream Management (SVSM)	Lean Service (VSM, Lean Principles)	Lean Service in Public Service	Service process identification, Current state mapping (SVSM), Waste analysis, Future state design,

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Author	Journal Title	Tools	Research Object	Lean Implementation Framework
			Organizations in Sweden	Improvement implementation (Kaizen), Monitoring and evaluation, Standardization and dissemination

III. RESEARCH METHODOLOGY

This study employs a qualitative exploratory method by reviewing previous research literature to identify lean implementation frameworks that can be adapted to lean education. The lean education framework is developed based on a comprehensive review of relevant literature and supported by the results of interviews and Focus Group Discussions (FGDs) with experts in the field. Once the proposed framework is constructed, it is subsequently validated by experts to ensure its relevance and applicability within the context of vocational education.

IV. RESULT AND DISCUSSION

A Lean Framework typically serves as a roadmap, guiding organizations on how to implement lean manufacturing by outlining the sequence of lean tools to be introduced within the organization [1]. The following are several lean frameworks from previous studies that have been adapted to the field of education:

1. [2] This study proposed a generic framework for applying lean in education that can adapt to different vocational high school settings. The framework consists of three main stages:

    a. **Preparation Stage** – Includes strategic planning, forming an implementation team, and providing lean training.
    b. **Design Stage** – Involves mapping using *Value Stream Mapping (VSM)*, conducting business analysis, and planning for change.
    c. **Implementation Stage** – Includes pilot projects, evaluating results, and expanding lean implementation throughout the system.

2. [5] proposed a lean framework by integrating Value Stream Mapping (VSM) as a lean management tool to analyze and improve the flow of materials and information in laboratory learning processes. The stages of this framework are as follows:

- Step 1: Planning and Cross-Functional Team Formation – Establishing a team consisting of educators, administrators, and quality assurance experts.
- Step 2: Value Stream Mapping (VSM) – Mapping the current state, identifying inefficiencies, and designing a more optimal future state.
- Step 3: Improvement Strategy Implementation – Identifying improvement opportunities, developing an action plan, implementing changes, and monitoring the results.
- Step 4: Lean Culture Adoption – Embedding a culture of continuous improvement within the institution.

The results of this study show that the model is capable of identifying waste in laboratory activities, improving efficiency, and assisting institutions in enhancing student learning outcomes.

3. [7] proposed a framework for applying Lean Principles and Practices to improve the quality of courses in business schools. The proposed framework includes:
    a. Identifying waste in teaching, such as ineffective teaching methods, redundant content, and inadequate assessments.
    b. Applying the Value Stream Mapping (VSM) concept to analyze and improve the efficiency of the learning process.
    c. Continuous improvement through the PDCA (Plan-Do-Check-Act) cycle.

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d. Focusing on student satisfaction as the primary customer by redesigning the curriculum and teaching methods to respond more to their needs.

Based on the results of the literature review, the main stages of lean implementation across various fields can be categorized into pre-implementation, implementation, and post-implementation phases. The following stages of lean framework development, as can be seen in Table 4 are validated by experts, are adopted from previous studies:

Table 4 Framework of Lean Education Stages in Vocational High School (SMK) Learning

Step	Details Steps	Reference
Pre Implementasi	Identifying problems or waste	[2], [6]
	Staff training and lean introduction	[3], [5]
	Initial process mapping	[2], [7]
	User needs analysis	[2], [5]
	Formation of lean improvement team	[5], [6]
Implementasi	Executing process mapping results in identifying and eliminate waste	[2], [3]
	Solution development	[2], [6]
	Use of lean tools	[5], [6]
	Active stakeholder involvement	[5], [7]
	Pilot Project	[6], [7]
Post Implementasi	Evaluation of implementation results	[6], [7]
	Continuous Improvement	[2], [5]
	Documentation of results and dissemination of best practices	[5], [7]
	Strategy adjustments	[5]
	Model replication to other programs or units	[5]

V. CONCLUSION

This study has produced an implementation framework for lean education specifically designed for practical learning activities in Vocational High Schools (SMK). The framework consists of three main stages—pre-implementation, implementation, and post-implementation—each comprising sub-stages such as waste identification, staff training, initial process mapping, lean strategy execution, and continuous evaluation and improvement. The framework was developed through an in-depth literature review and validated by experts in vocational education and lean methodology. The results of this study are expected to provide a tangible contribution to improving the efficiency and effectiveness of practical learning in SMKs, and to serve as a strategic reference for schools in reducing waste commonly found in the learning process. Furthermore, this framework can serve as a starting point for the development of a more industry-responsive vocational education system. A suggestion for future research is to conduct empirical testing of this framework across various vocational high schools (SMKs) with different characteristics, and to integrate a quantitative approach to measure the effectiveness of the framework's implementation more objectively and measurably.

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