LEAN WASTE IDENTIFICATION IN HIGHER EDUCATION INSTITUTION USING WASTE ASSESSMENT MODEL

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Abstract:
Lean is a philosophy that is seen as a solution to resolve the problem of efficiency in various industries. It can be used to eliminate all forms of waste in the workplace. The implementation of lean is not only applied in manufacturing but is very important to be applied in other fields, such as in Higher Education Institution. Studies on the topic of lean in the workplace have been carried out, but most of the study has been conducted within a manufacturing context. This study aims to determine the type of waste that is most important to be eliminated first by using the Waste Assessment Model and find the root of the waste problem. This study developed the relationship between waste and find out the effect of waste on each other in Higher Education Institution that focused on teaching and learning process. The steps of this study consist of three-step, such as waste identification, waste assessment, and root cause analysis. From data collection show that there are 46 forms of waste in the teaching and learning process. The results of the Waste Relationship Matrix showed three types of waste must be removed first, namely overproduction, defects, and non-utilized talents. 5-Why's is used to find out the root causes of waste which is the most important to be eliminated first in the teaching and learning process.

Key words: lean, waste, waste assessment model, 5-why's, higher education institution

INTRODUCTION

Lean principles and practices have been discussed in public and private organizations over the past decades. It was introduced by Toyota as known as "Toyota Way" to achieve operational excellence. Lean is a philosophy to make continuous improvement in a workplace to make the best use of resources [1]. The goal of lean is to reduce all forms of activities that do not add value to the final product according to customer desires [2]. So, it can be said that lean is a philosophy that is used to eliminate all forms of waste that have an impact on the final product that the customer wants by using the best possible resource.

Lean and waste are two related terms. Waste is all activities that do not add value to a process and carrying out these activities requires time and money [3]. In the lean principle, waste must be eliminated [4]. So, it can be said that all activities that do not provide added value (waste) must be eliminated because doing these activities requires time and money.

Lean principles are increasingly being seen as a solution to resolve the problem of efficiency in various industries. This can be seen from the many studies that use lean to reduce waste as their research topics. LM implementation began in the automotive industry. The Lean concept developed in Japan after World War II. Moreover, implementation of LM spread out other industries, including textiles, construction, food, medical, electricity and electronics, ceramic industry, plywood, furniture, slippers, shell, and the service industry [5, 6, 7, 8, 9].

Currently, there are seven types of waste, namely overproduction, waiting, transportation, excess processing, inventories, motion, and defects [10] However, following the times and the development of needs, the seven wastes are developed into eight [11]. Eight wastes have now been widely applied in various sectors, including Higher Education Institution (HEI). The eight wastes are defects and rework, over-production, waiting, non-utilized talents, transportation, inventory, motion, and extra processing [12]. Lean can be implemented to identify and

eliminate waste for continuously improving process quality in HEI. Limited study of the lean in HEI has been carried out such as the study by Douglas et al. [13], Kazancoglu et al. [14], Zighan et al. [15], Narayanamurthy et al. [16]. Even though those studies focused on lean in HEI, none of them have done assessments based on the relation among the waste. This study addresses this gap by developing the relationship between waste and find out the effect of waste on each other.

WASTE IN HIGHER EDUCATION INSTITUTION

The process at HEI is complex that crosses functional and departmental boundaries, this has the consequence that the process becomes longer and the stages become more numerous [13]. Lean and Higher Education sector are close to each other which known as Lean Higher Education (LHE). The lean implementation brings benefit to HEI, such as improve operational processes, maintain competitiveness, obtain customer satisfaction, achieve best performance [12, 13, 16, 17]. Waste in the HEI has a different understanding from manufacturing or other service sectors. Several articles explained the waste in higher education institutions such as [12, 13, 15, 16, 18]. Douglas et al. In [13] waste was divided into eight categories such as excess motion, excess transportation, underutilized people, inventory, defects, overproduction, waiting, over-processing. Narayanamurthy et al. [16] modified seven wastes in the manufacturing sector becoming waste in educational institutions, those are rework, motion, waiting, over-processing, over-production, and defect. In [14] waste category in higher education was divided to eight wastes in the manufacturing sector: overproduction, over-processing, waiting, motion, transportation, inventory, defects, and talent.

WASTE ASSESSMENT MODEL

Waste Assessment Model (WAM) was developed by Rawabdeh [19] to identify critical waste in order to create solution in eliminating waste. WAM consists of Waste Relation Matrix (WRM) and Waste Assessment Questionnaire (WAQ). All types of waste are interdependent, and each type has influence on the other and simultaneously in influenced by the others, and relationship each category of waste are not equal weights [19]. The waste relationships are assessed using questionnaire and the weight of answer ranging from zero to four [19]. WAQ consists of several different questions for the purpose of allocating

waste. These questions constitute a condition activity or behavior that can produce a certain waste.

METHODOLOGY OF RESEARCH

This study was conducted at two faculties of an HEI in Surabaya, East Java, Indonesia, focused on teaching and learning process and initially divided into three steps as summarized in Table 1.

Table 1
Steps in this study

Step	Techniques
Waste Identification	Random observation, Interviews, Gemba, Literature Review, Questionnaire.
Waste Assessment	Waste Relationship Matrix (WRM), Waste Assessment Questionnaire.
Root Cause Waste	5-Why's

First, waste identification is conducted by random observation, interviews, Gemba, and literature review. Then design waste identification questionnaires and distribute them to respondents. Waste WRM is used to determine the relationship among the waste. Root cause analysis is conducted to determine the root cause of the most waste be removed first because it can generate other types of waste. To find out the critical waste to be eliminated first can be seen in the WRM in the total score section which has the largest percentage value. Root cause was conducted by using 5-why's.

RESULT AND DISCUSSION

Waste Identification

Waste identification was conducted by several techniques such as random observation, interviews, Gemba, a literature review that has done by previous researchers, such as Robinson & Yorkstone [1], Douglas et al. [13], Höfer & Naeve [12], and Kazancoglu et al. [14]. Tabel 2 shows several wastes in HEI. Then the result of the waste identification process was used to design the questionnaire.

The questionnaire consists of eight types of waste that break into 46 Questions (Table 3).

A waste identification questionnaire was distributed to all members of faculties to find out the major waste and collected 31 faculty members (Table 4).

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 the absence/canceling of 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.
		Lecturers have experienced a shortage of exam scripts.
2	Overproduction	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 changes.
		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.
		Students are late in submitting assignments.
4	Non-Utilized Talent	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.
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.
8	Extra Processing	Lecturers look for documents/files/journals for a long time.
		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.

Table 3
Number of Question

No	Type of waste	Number of question
1	Defects	12
2	Overproduction	6
3	Waiting	9
4	Non-Utilized Talent	3
5	Transportation	1
6	Inventory	5
7	Motion	2
8	Extra Processing	8

Table 4
Respondent's Answer

Category of Waste	Question No	No of Respondent			
		Very Frequently	Frequently	Rarely	Never
Defect	1	0	4	20	7
	2	0	0	12	19
	3	0	0	16	15
	4	0	1	25	5
	5	0	0	12	19
	6	0	0	13	18
	7	0	4	21	6
	8	0	3	18	10
	9	0	0	21	10
	10	0	3	22	6
	11	0	6	16	9
	12	0	3	13	15
Overproduction	13	0	4	14	13
	14	0	0	11	20
	15	0	4	16	11
	16	3	8	7	13
	17	0	2	2	27
	18	2	15	13	1
Waiting	19	0	3	20	8
	20	0	1	22	8
	21	0	8	16	7
	22	0	4	17	10
	23	0	7	18	6
	24	0	4	16	11
	25	1	7	21	2
	26	0	9	21	1
	27	0	15	16	0
Non-Utilized Talent	28	2	4	17	8
	29	0	4	15	12
	30	1	2	17	11
Transportation	31	1	4	9	17
Inventory	32	0	4	16	11
	33	6	14	6	5
	34	1	4	16	10
	35	0	5	17	9
	36	1	5	21	4
Motion	37	0	7	13	11
	38	1	8	15	7
Extra processing	39	0	6	22	3
	40	1	5	11	14
	41	6	15	8	2
	42	1	4	17	9
	43	3	6	17	5
	44	0	11	17	3
	45	0	3	18	10
	46	0	0	24	7

Validity Test

The validity test needs to be done after distributing the waste identification questionnaire. The validity test is a test to determine the accuracy between the data obtained and what the study reported [20]. The results of validity test showed that all aspects of the question have exceeded the r table, it means valid.

Reliability Test

The second test is the reliability test. In contrast to the validity test, the reliability test is a test to determine the level of consistency of the questionnaire answers answered by a respondent [21]. The reliability test was carried out using SPSS software. The SPSS results showed that the Cronbach Alpha obtained is 0.926 where the value is more than 0.6. So it can be said that the results are reliable.

Below Table 5 states the rank of waste that affects the higher education institute. The majority of respondents stated that three waste such as defect, waiting and extra processing are the major waste that occurred in the higher education institute. The overproduction, inventory, non-utilized talent, motion, and transportation waste are ranked as 4, 5, 6, 7, and 8 respectively.

Table 5
Rank of Waste

Category of Waste	Total Score	Rank
Defect	629	1
Overproduction	330	4
Waiting	565	2
Non-Utilized Talent	171	6
Transportation	51	8
Inventory	319	5
Motion	123	7
Extra processing	515	3

Waste Relationship Matrix (WRM)

It is very important to find out the major waste that has the highest influence on the overall process in HEI. The waste Assessment Model (WAM) is used to find out the effect of waste on each other. All types of waste influence the others and simultaneously is influenced by the others and the relationship among wastes in complex because the influence of each category can appear directly or indirectly [19]. Based on the study of Rawabdeh [19] and brainstorming among the head of Faculties and Department then the model of the relationship among category was developed based on the category of waste shown in Figure 1.
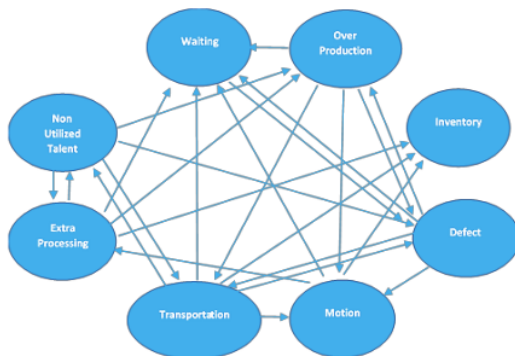
Fig. 1 The Relationships of Eight Wastes in Teaching and Learning Process

Data collection for waste assessment was carried out using a questionnaire to determine the effect of one type of waste on other types of waste. It was distributed to the head of Faculties and Department and feedback received from them was used for analysis. Each question in the questionnaire has a score that will be used to calculate the total score for each waste type relationship. Table 6 below is the result of the average score for each relationship among the waste. After distributing the questionnaire, the following is done in calculating the total score for each respondent.

Table 6
Average Score Calculation of WRM

No	Relationship	Average Score	No	Relationship	Average Score
1	O_I	8	14	T_I	10
2	O_D	9	15	T_D	6
3	O_M	11	16	T_M	5
4	O_T	9	17	T_W	4
5	O_W	9	18	T-Ta	4
6	D_O	10	19	P_O	6
7	D_M	8	20	P_I	8
8	D_T	10	21	P_W	7
9	D_W	9	22	P_Ta	8
10	W_D	7	23	Ta_O	10
11	M_I	11	24	Ta_D	11
12	M_P	7	25	Ta_T	6
13	M_W	8	26	Ta_P	9

From Table 6 above, there are several notations such as O which indicates overproduction, I which indicates inventory, D which indicates defect, M which indicates motion, T which indicates transportation, P which indicates extra processing, W which indicates waiting, and Ta which indicates non-utilized talents.

The measurement criterion analysis was organized in Waste Relationship Matrix (WRM). Table 7 shows the WRM.

Table 7
Waste Relationship Matrix

F/T	O	I	D	M	T	P	W	Ta
O	A	O	I	I	O	X	O	X
I	X	A	X	X	X	X	X	X
D	I	X	A	O	I	X	I	X
M	X	I	X	A	X	O	O	X
T	X	I	O	O	A	X	U	U
P	O	I	X	X	X	A	O	O
W	X	X	O	X	X	X	A	X
Ta	I	X	I	X	O	I	X	A

The next thing to do when you have obtained a matrix containing letters is to convert these letters into numbers. The letter A will be converted to the number 10, the letter E to the number 8, the letter I to the number 6, the letter O to the number 4, the letter U to the number 2, and the letter X to the number 0 [19].

Table 8 explains the type of waste in the form of overproduction is the type of waste that is most capable of causing the emergence of other types of waste. This is because the "from" score of overproduction waste reaches a value of 16.83% where this value is the greatest value when compared to the "from" score of other types of waste. For other types of waste, waste with defect types and non-utilized talents can affect the appearance of other types of waste by 15.84%, waste with transportation and extra processing types can affect the appearance of other waste by 13.86%, waste with motion types can affect the appearance of other waste was 11.88%, the waiting type of waste could affect the appearance of other types of waste by 6.93%, and the waste with the inventory type could affect the appearance of other types of waste by 4.95%. It can be seen that over production, defects, and non-utilized talents are the three critical waste.

Table 8
Waste Matrix Value

F/T	O	I	D	M	T	P	W	Ta	Score	Score (%)
O	10	4	6	6	4	0	4	0	34	16,83
I	0	10	0	0	0	0	0	0	10	4,95
D	6	0	10	4	6	0	6	0	32	15,84
M	0	6	0	10	0	4	4	0	24	11,88
T	0	6	4	4	10	0	2	2	28	13,86
P	4	6	0	0	0	10	4	4	28	13,86
W	0	0	4	0	0	0	10	0	14	6,93
Ta	6	0	6	0	4	6	0	10	32	15,84
Score	26	32	30	24	24	20	30	16	202	100
Score (%)	12,87	15,84	14,85	11,88	11,88	9,90	14,85	7,92	100	

Root Cause Waste Analysis

Root cause waste analysis is conducted to determine the root cause of waste which is most capable of generating other types of waste. To find out the root causes of the most important waste, an analysis was carried out using the 5 Why's method based on brainstorming with the head of faculty and department. Table 9 below is a 5-why's table that has been formed from the results of the author's brainstorm.

Table 9
5-Why's

No	Critical Waste	Why 1	Why 2	Why 3	Why 4	Why 5
1	Overproduction	Because many lecturers often do administrative tasks outside of working hours.	Because the lecturer hopes that the assignment can be completed.	Because lecturers want not to interfere with lecture activities	Because the lecturer wants to focus on giving lectures	Because lecturers want to serve students well
2	Defect	Because lecturers often find inaccessible documents	Because the computer used by the lecturer is damaged	Because of a lecturer error in using the computer	Because there is an assignment that the lecturer wants to complete immediately	Because the lecturers have a lot of work to do
3	Non-Utilized Talent	Because lecturers often encounter assignments that are not in accordance with their scientific field	Due to a lack of educators	Because many lectures are currently taking study	Because they want to improve work professionalism	Because it takes quality student output

CONCLUSION

There are 46 forms of waste identified in the teaching and learning process of HEI. According to Waste Assessment Matrix, there are three types of waste that are most important to be eliminated first, namely waste with the types of overproduction, defects, and non-utilized talents which can influence the appearance of other types of waste, respectively 16.83%, 15.84% and 15.84%. The root cause of the overproduction type of waste is the desire of the lecturer to serve students well, for waste with the defect type is the number of tasks that must be completed by a lecturer and for waste with the type of non-utilized talent because it requires quality student output. There are several suggestions that can be given for future research. This research is limited to the teaching and learning process and for further research, study can be carried out for other processes in educational services. Besides that for the next research, it can be explored further regarding the relationship among waste in HEI.

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