Research Article

Managing the 8 Wastes of Lean at a Higher Education Institution: An ISM-MICMAC Approach

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Abstract.
A Higher Education Institution (HEI) is required to be more competitive in maintaining its sustainability. The large number of stakeholders of an HEI makes it difficult to be agile in the intense competition. One of the concepts that can be used to improve the agility of an HEI is the Lean philosophy. Lean philosophy focuses on eliminating waste in the process of creating value for stakeholders. Previous research has identified several wastes in the operational activities of an HEI. This study aimed to develop a series of actions to eliminate wastes that have been identified. Interpretive Structural Modelling (ISM) and Matrices Impacts cross-multiplication applique classmate (MICMAC) are employed to model the relationship between wastes based on their mutual influence. ISM forms a hierarchical structure of interrelationships between wastes. Meanwhile, MICMAC will classify wastes based on their level of influence in a cartesian diagram. These models will help to analyze the root cause of the problem so that effective waste elimination actions can be arranged.

Keywords: Higher Education Institution, Lean, Waste, MICMAC, Lean Philosophy

1. INTRODUCTION

Lean manufacturing is a management practice that focuses on increasing value for customers through waste elimination [1]. This concept emerged when the automotive industry had to fight in a competitive global market [2]. Today when 'quality of life' is becoming so important for the society, the service industries are under the spotlight to improve their process quality in order to survive in the business competition [3]. To achieve this goal, lean principles that have successfully implemented in various manufacturing industries, are introduced in the service industry and later known as lean service [4]. Lean service then developed into one of the most reliable alternative approaches to improve the effectiveness and the efficiency of service industry. Practically, lean service is related to standardization of work processes so that critical

problems in the organization are clearly visible and human resources are stimulated to think critically in solving problems and in improving work flow [5]. Lean principles are easily adapted in various service sectors. Scientific publications prove that lean service is successful in improving the quality of operations in various service sectors, ranging from commercial ones such as hotel [6], hospital [7], bank [8], school [9] to public services [10]. Among the various service sectors, the implementation of lean service that is being developed is in higher education institutions (HEIs) [11]. The implementation of lean service in HEIs is known as Lean Higher Education (LHE) [12]. LHE stems from the many HEIs that are committed to improve their process because they are considered to be inefficient, expensive, and labor intensive [13]. On the one hand, society is required to be more 'knowledgeable', but on the other hand the economic challenges encourage them to look for institutions that provide affordable education. Therefore, HEIs face tremendous

challenges and are under pressure to become more responsive to customer needs and gain excellence [14]. Improvement efforts initiated by HEIs are often underestimated because they often last in the short term and end in failure. In fact, HEIs have a lot of potential for driving LHE initiatives because lean management has been included in the curriculum at various HEIs in the world [15].

HEIs have benefited greatly from the implementation of LHE [16]. Balzer et al. [13] conducted a study on five cases of implementing LHE in the USA and found that LHE provided benefits for universities, employees, and individuals served. Furthermore, Allaoui and Benmoussa [17] found that college employees were motivated to make changes with LHE due to high level of education, dissatisfaction with working conditions, good impression on the change project, curiosity, good relationship with management, lack of routine, good relationship with co-workers, and its positive impact on employees. However, the implementation of LHE has more challenges than lean services in general. Waterbury [18] identified eight challenges that emerged in implementing LHE in seven HEIs: scheduling, time, lean competency, competing needs, seeing differently, skilled facilitators, financial resources, and project selection. The challenge arises because education is a service that has many stakeholders both inside and outside the organization with several conflicting objectives [19].

Different HEIs also lead to differences in the approaches, methods, and practices used in the implementation of LHE [20]. However, the main objective of implementing LHE has been agreed: to add value to stakeholders by reducing waste so that HEIs get the opportunities to improve academic and administrative processes [21]. The eight

waste categories that appear in HEIs are identified as excess transportation, under-utilized human resources, inventory, excess motion defects, overproduction, waiting, over processing, and excess information [22]. These wastes resulted in disruption of administrative and academic processes so as to create stakeholder dissatisfaction. Therefore, HEIs must not only identify the wastes but also must find a way to eliminate the wastes so that continuous process improvement can occur. Kazancoglu and Ozkan-Ozen [23] identified wastes in a HEI in Turkey and used a fuzzy decision-making trial and evaluation laboratory (DEMATEL) in building a structural model that was used as the basis for proposing actions to eliminate wastes. However, the weakness of the structural model produced by DEMATEL only classifies factors based on the magnitude of the influence. DEMATEL cannot identify the interplay factors in a structural model. Klein et al. [24] proposed a waste management framework for a HEI in Brazil which was built using Analytical Hierarchy Process (AHP) method. The weakness of the proposed waste management using the AHP method is that waste management will start from the waste that is considered to have the highest subjective importance and ignore the interrelationship with other wastes.

One of the proposed approaches to find ways in waste elimination is Interpretive structural modeling (ISM). Rawabdeh [25] states that all types of waste are interdependent, and each type has an influence on each other; and simultaneously influenced by others. ISM is a method for modeling direct and indirect relationships between various factors. ISM describes a hierarchical structure and partition level so as to visualize the implementation structure in a better way [26]. The use of ISM which is integrated with the Matrice d' Impacts Croisés-Multiplication Appliquée á un Classement (MICMAC) has proven to be effective in finding solutions to a problem [27]. Jadav et al. [28] used the ISM-MICMAC approach in designing a framework for implementing lean management. In this study, ISM and MICMAC are used to model the structure of the relationship between wastes in a HEI that so that the root causes of the problem can be identified and a series of waste elimination actions can be proposed.

2. METHODS

The description of the research design follows the classification in the research onion [29]. The research strategy is a single case study with a cross sectional time horizon. The case used in this study is a private HEI in Surabaya, Indonesia which has been accredited A. Stakeholder expectations for A-accredited HEIs will be very high. Therefore, an A-accredited HEI can become a single extreme case study that can provide insights as

well as lessons learned regarding the issue of lean waste management in HEIs. The selection of an A-accredited HEI was carried out by convenience sampling.

The stages of this research start from determining eight categories of waste: defects, overproduction, waiting, non- utilized talent, extra transportation, excess inventory, extra motion, and extra processing. Then, the identification of waste modes in each waste category is carried out through unstructured interviews and direct observation. Furthermore, a structural model was developed for the identified waste modes using Interpretive Structural Modeling (ISM) approach. The purpose of developing the structural model is to find a set of waste elimination actions. The ISM procedure begins with establishing the relationship between waste modes through a focus group discussion (FGD) from a panel of expert. The panel of expert determines the relationship between waste modes through pairwise comparisons using four symbols: V (waste i influences waste j, but waste j does not influence waste i); A (waste j

influences waste i, but waste i does not influence waste j); X (waste i influences waste j and waste j influences waste i); O (waste i and waste j are not related and vice versa).

The result of the FGD is a structural self-interaction matrix (SSIM). The SSIM is then converted into an initial reachability matrix (IRM). IRM shows the relationship from waste i to waste j expressed in binary (0 or 1). The IRM then checked for its transitivity. Transitivity is expressed if A is related to B and B is related to C, then A is also related to C. The IRM whose transitivity has been checked is called the final reachability matrix (FRM). Once the FRM is formed, the next step is to determine the reachability set (R), the antecedent set (S), and the intersection (R∩S). The reachability set is a series of waste modes in a column where all waste modes in row i of FRM have a value of 1. The antecedent set is a series of waste modes in a row where all waste modes in column j of FRM have a value of 1.

After getting R, S, and R∩S, the hierarchical structure can be determined. The order starts at level-I which is placed at the top of the hierarchy. The selected waste modes are the waste modes that have R equal to R∩S. For the next iteration, waste modes that have entered level-I are removed from the FRM and the same process is carried out starting from determining R, S, and R∩S. And so on until the level for all waste modes is determined.

FRM is also used to construct a MICMAC cartesian diagram. MICMAC cartesian diagram is used to classify waste modes into four groups: autonomous, dependent, linkage, and driver. Cluster I, autonomous, consists of waste modes with weak driving power and dependency. Cluster II, dependent, consists of waste with weak driving force but strong dependence. Cluster III, linkage, consists of waste modes with a strong

driving force and dependence. Finally, cluster IV, driver, consists of waste modes with a strong driving force and weak dependency.

3. RESULTS

Table 1 shows 18 waste modes identified through interviews and observations. The waste modes are then ranked based on the frequency of their occurrences from the observations. The waste category that does not bring up the waste mode from the results of interviews and observations is extra transportation. Thus, extra transportation is not a significant waste category in this case. Meanwhile, the category of waste that produces the most waste modes is waiting.

4. DISCUSSION

The series of waste elimination actions proposed in this study are not based on the waste modes ranking but based on the hierarchical sequence of waste modes generated from the ISM method. The hierarchical structure model helps identify the end of the problem so that the proposed action starts from the end of the problem that has the greatest impact. The end of the problem is the waste mode that affects the emergence of other waste modes. The waste hierarchical structure model generated through the ISM approach consists of eight levels (see Fig. 1). The waste mode at level-VIII is the waste mode that affects the waste modes at the upper level. Meanwhile, the waste modes at level- I are the waste modes that are influenced by waste modes at levels below it. Thus, the sequence of waste elimination will start from level-VIII to level-I.

The MICMAC diagram supports the interpretation of the hierarchical structure regarding the magnitude of the influence of each waste (see Fig. 2). In the MICMAC diagram, waste modes are grouped into 4 clusters: autonomous, dependent, linkage, and driver. These results support the waste hierarchical structure model. Waste modes at level- VIII, level-VII, and level-VI are grouped in the driver determinant. This is in line with the ISM hierarchical structure that the waste modes at the lower level have the great influence. Waste modes at level-V, level-VI, and level-III, level- II, and level-I are included in the linkage and dependent determinants so that they act as interplay in the relationship between waste modes. Eventually, waste modes at level-I, level-III, and level-VII are grouped in the autonomous determinant.

TABLE 1: Identified waste modes.

Rank	Waste Category	Waste Mode
1	Overproduction	Working outside the hours to perform administrative work
2	Waiting	Facility repairs take a long time
3	Non utilized talent	The lecturer does not participate in community service every semester
4	Defects	The lecturer is unable to locate a file
5	Defects	The projector's connecting wire is faulty
6	Waiting	The lecturer fails to submit reports by a stipulated deadline
7	Extra processing	The lecturer spends a lot of time looking for documents, files, and journals
8	Waiting	The lecturer takes a long time to respond to student messages and questions
9	Extra processing	Multiple information channels are used to receive information (WhatsApp, email, hard copy, etc.)
10	Overproduction	Every semester, the teaching load is overwhelming
11	Inventory	The lecturer uses the same exam questions from the previous year
12	Waiting	Assignments are not submitted on time by students
13	Non-utilized talent	Every semester, the lecturer does not undertake research
14	Defects	The course schedule is changed by the lecturers
15	Defects	Students are re-examined by the lecturer
16	Waiting	The lecturer is late in meetings
17	Waiting	The lecturer waits for students to come in to class
18	Non-utilized talent	The lecturer is assigned a task outside of their expertise

5. CONCLUSION

The combination of the ISM and MICMAC approaches has successfully supported the development of a set of actions to eliminate waste and improve processes. Determination of standard procedures for repairing damaged campus facilities, the need to consider excess activity from teaching and learning activities in the teaching assignments, integration of information systems, and development of learning management systems are proposed as waste elimination actions. Implementation the proposed actions are expected to eliminate the 18 identified waste modes and improve the process. This study also found that there was no relationship between the waste mode rankings and the hierarchical structure model generated from the ISM. Waste modes that often appear do not necessarily have a strong influence on other waste modes and vice versa. Practically, this research can be directly applied to the HEI under study and other HEIs that face similar problems. Methodologically, this research is expected to provide
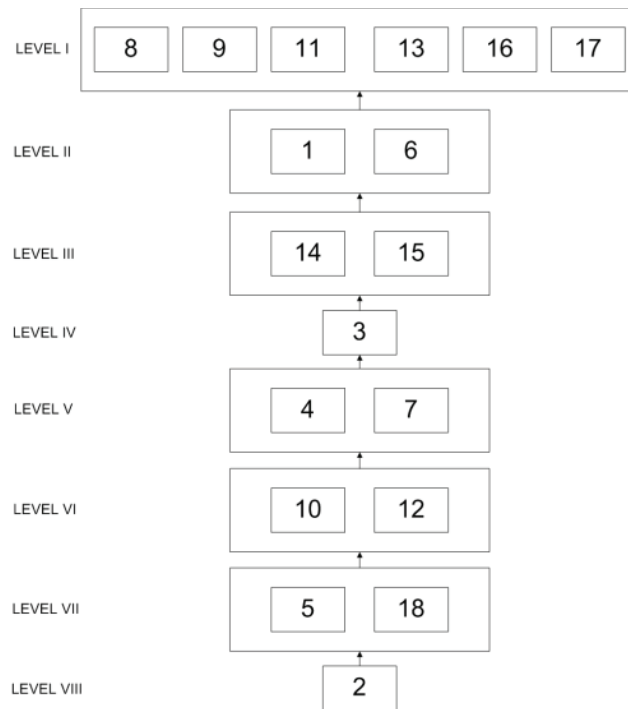
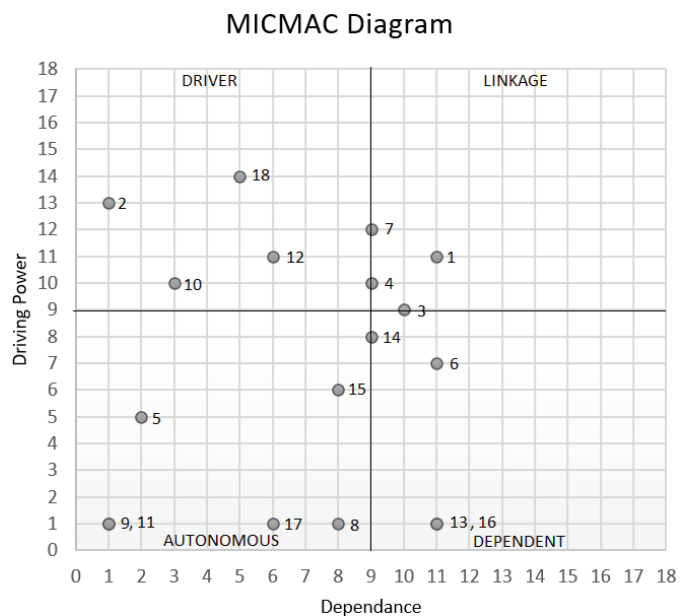**Figure** 1: The waste hierarchical structure.

Figure 2: MICMAC cartesian diagram.

insight into how the ISM-MICMAC approach is used as the basis for formulating effective actions in the idea of lean management. The limitation of this research is to see waste modes only from the lecturer's perspective. The suggestion for further research is that waste identification is carried out not only from the perspective of lecturers but also from the perspective of other stakeholders in the HEIs.

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