Value Stream Mapping:
Effective Process Improvement Tool in the Certification Process

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ABSTRACT[1]

The potential of the construction industry resides in the knowledge, skills and abilities of its specialists. Certification bodies of construction specialists have become interested in using Lean methodology in order to measure or monitor their services efficiency. The aim of this case study is a practical demonstration of the Value Stream Mapping method or visualization and rationalization of the competence assessment process of construction specialists in order to develop possible solutions for the improvement of the certification process. The main finding is – the professional competence assessment process of construction specialists contains activities which are non-value-added and do not ensure compliance of the professional competence assessment procedure to the requirements laid down in the professional sphere.
Identification of the performance of the competence assessment process of construction specialists was made using Value Stream Mapping in order to visualize the activities creating value, as well as difficulties and challenges in each of the process stages of the competence assessment process in the construction field.

Keywords: person certification, construction, lean methodology, value stream mapping.

1. INTRODUCTION

Service failures are, at times, a considerable problem in every service industry and they can influence consumers' future choices, lead to enhanced negative word of mouth as well as lower satisfaction and higher customer turnover [33]. At present, when competence evaluation and social responsibility are the biggest challenges under the influence of globalization processes, competence assessment service organizations are able to measure or monitor their services efficiency [18], [19], [13], [20]. Due to the fact that the engineering and construction industry is classified as a huge consumer of natural resources, where costs of ineffective management can be very high, engineers play a key role in new knowledge creation and innovation processes [14], [23], [28]. Consequently, the construction industry and related service industries are confronted with challenges associated with the inclusion of non-value adding activities and processes resulting in inefficiency and low productivity [3]. Because faulty operation in construction may cause serious risks, there is a need for a professional qualification certificate stating the person's competence in the sphere. However, not always the certificate issued by a certification body confirms the person's compliance with the professional competence requirements laid down in the industry, whereas it protects the employee from the consequences that may result from incompetent professional performance [7]. Nowadays the potential of an organization resides in the knowledge, skills and abilities of its specialists, therefore certification bodies of construction specialists have become interested in using methods of lean management in order to eliminate waste and find significant savings [30], [25], [8].
The aim of this article is a practical demonstration of the Value Stream Mapping method or visualization and rationalization of the competence assessment process of construction specialists in order to develop possible solutions for the improvement of the certification process. This research aims to answer the question: which activities of the competence assessment process of construction specialists are not value-added and do not ensure compliance of the professional competence assessment procedure to the requirements laid down in the professional sphere.
Identification of the performance of the competence assessment process of construction specialists was made using Value Stream Mapping in order to visualize the activities creating value, as well as difficulties and challenges in each of the process stages of the competence assessment process in the construction field.
This method was chosen because of its wide application in the research of theoretical and practical aspects of any topic and due to the fact that this method is able to provide

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an in-depth concept of the main problems in the research area.

In Section 2 the authors introduce the basic information on the role of Lean management in the process improvement and give a short notation of the professional competence assessment process applied in the certification process of construction specialists. The basic information on the applied research methods is given in Section 3; while in Section 4 the authors introduce the results of Value Stream mapping in order to give the evaluation of how the professional competence assessment process of construction specialists is organized. In Section 5 the authors offer their conclusions.

2. THE ROLE OF LEAN MANAGEMENT IN THE PROCESS IMPROVEMENT

Lean emerged as one of the most dominant managerial paradigms in business environments as extensive theoretical and empirical evidence has demonstrated its effectiveness to enhance the competitiveness of organizations [6], [15]. To achieve this, Lean focuses on fierce reduction of non-value-added activities, i.e. waste, and relies on an extensive set of tools and techniques. The key idea of Lean is that there are two different types of efficiency: resource efficiency and flow efficiency, but Lean highlights the meaning of flow efficiency, which is defined as the percentage of the time of value-added work out of the whole process end-to-end time [32], [29]. This systematic approach focuses on doing more with fewer resources by eliminating non-value-added activities and wastes and various lean tools and techniques have been developed for process improvement [26], [34]. Consequently, process quality improvement can be achieved reducing process failure, the Lean methodology can be applied by organizations for different purposes [35], and it could be implemented in different fields in order to improve the concrete process (see Table 1).

Table 1. The Lean management methodology – supporting research

Purpose	Field	Benefit/ Key findings	Refe-rence
To analyse complex value streams and create improvement ideas.	Information technology	Opportunity to analyse the intangible and fuzzy aspects of the value stream and better support for systematic improvement idea generation.	[32]
To eliminate non-value-adding waste in service process.	Medicine	Elimination of waste and opportunity to disclose how the current process actually works and performs.	[31]
To reduce losses and wastes in order to establish links with nutrient retention in supply chains.	Agri-food industry	Minimization of wastes and improvement of multi-stakeholder collaboration along the entire supply chain.	[29]
To analyse and design value streams in order to reduce waste.	Logistics	Elimination of waste and reduction of lead time and presentation of value flow in a company and generation of small and continuous improvements of the current process.	[9] [25] [15]
To analyse value-added and non-value-added activities in the current process.	Automotive industry	Identification and elimination of waste activities through continuous improvement.	[24]
To get an overview of the delivered performance.	Service industry	Identification of the potential for optimization concerning queries in process.	[21] [33] [5] [2]
To provide effective ways in order to establish strategic directions for better decision making and work design.	Manufactu-ring industry	Improvement of the value stream and the performance of the manufacturers.	[26] [11] [10] [8] [6]
To enable the mapping and analysis of process chains in order to derive potentials for improvement.	Information logistics	Analysis and visualization of the current state of value streams, in terms of material and especially information flows.	[17]
To improve organizations' performance.	Entrepre-neurship	Improvement of process effectiveness and change of organizational routine.	[1] [4]
To achieve a new holistic view of sustainability as an integration of process efficiency (cost, time, quality).	Construction industry	Reduction of non-value-adding activities and the contribution of the process to the society and economy, in addition to environmental conservation.	[14] [16] [3] [22]

After analysing the basic professional competence assessment methods, it was considered that the Lean management tools have been widely used in many industry sectors in order to apply them in solving different kinds of issues related to waste reduction.
From the analysis of the researches, the authors conclude that the implementation of the Lean approach provides effective ways to improve the performance of processes in different industries, capable to enhance the outcomes of many areas besides manufacturing.

3. THE LEAN METHODOLOGY AS AN EFFECTIVE WAY TO IMPROVE PROFESSIONAL COMPETENCE ASSESSMENT PROCESS

According to the requirements of standard ISO/IEC 17024 and normative acts, the certification process in construction should be organized so as to be able to assess the competence of persons to be certified with the help of objective assessment tools. In order to represent a confirmation of professional competences in the certification process, there is a need to analyse and evaluate the professional competence assessment process applied in the certification process of construction specialists. Previous research on service failures of the certification process [12], identified by Failure Mode and Effects Analysis (FMEA) and the Delphi method, did not examine how certification bodies can measure or monitor their service efficiency. Upon performing risk management methods, the authors concluded that the most typical failures with the highest risk priority assessment can be observed in the examination stage, the causes of which lie in inadequate work process organization.
In order to eliminate the impact of the above-mentioned factor as regards meeting the deadlines in organizing the competence assessment process of construction specialists in accordance with the normative acts, it is necessary to carry out an in-depth analysis of the organization of the examination process, visualizing the activities creating value, as well as difficulties and challenges in each of the process stages.
The data analysis consisted of Value Stream Mapping in which the main activities of the competence assessment process of construction specialists were analysed in order to improve the competence assessment process using the Lean methodology.

Applying Value Stream Mapping in analysing the professional competence assessment process

In recent years, interest in Value Stream Mapping (VSM) techniques has increased significantly. VSM is a lean manufacturing technique that since its creation has been used in many sectors of the industry and has emerged as the preferred way to support and implement the Lean approach [26]. This systematic approach focuses on doing more with fewer resources by eliminating non-value-added activities and wastes and it is a well-accepted, widely-used and holistic method for mapping, analysing and designing value streams in order to reduce waste [9], [24]. It is also a simple and visual process-based tool that enables the documentation, visualization and comprehension of the material and information flows in processes, in order to identify wastes and assist in their elimination with an emphasis on flow efficiency [6], [32]. The method originates from the Toyota Production System and it is based on close cooperation with the customer and a focus on the customer's point of view on process necessity, consists of two main phases [21], [8], [24]:

(1) the value stream analysis, in which the current value stream is visualized producing a diagram which represents the actual material and information flows of the current state on how the actual process operates,
(2) the value stream design, in which sources of waste within the process are uncovered and reduced producing a future state map through process improvements that could give a great impact to the process.

However, VSM can be seriously challenging when the process is complex and its ability to capture dynamics is limited, and the current quality control loops are not considered in the visualization [15], [8], [32]. The traditional VSM also lacks a practical way of modelling elements that are present in multiple steps of the value stream and a systematic approach to generating different types of improvement ideas [32].
In this paper, VSM was chosen because the evidence shows that VSM is the most suitable and most frequently used tool across industries [15]. In this research, it helped to identify and visualize the relationships between the professional competence assessment activities in the certification process in order to assess ways of improving the competence assessment procedures for certification of construction specialists in the future.

4. THE RESULTS OF VALUE STREAM MAPPING

In assessing the professional competence of construction specialists in the certification process, the authors decided that in addition to previous research on service failures of the certification process [12], it is necessary to analyse how the competence assessment process is performed by the certification body. The aim of the VSM method is to identify, visualize and analyse the activities creating value in the competence assessment process of construction specialists in order to eliminate non-value-added activities and wastes.
In order to be able to identify values and create a flow of the exam organization process without losses, it was necessary to identify the stages of the process where complications and problems may arise, as well as the consumed resources. In achieving the stated goal, the VSM method was applied, using the examination process organized by the Latvian Association of Power Engineers and Energy Constructors Certification Centre (LEEA SpecSC). The application of the method led to an understanding of how information circulates, as well as to the identification of areas where losses occur, at the same time minimizing the risk of inefficient and insignificant

improvements. The VSM method provides an opportunity to plan the state of future or desired processes using the current process flow and the identified losses that can be transformed into improvements.

The visualization of current state

Since the goal of VSM is to evaluate the processes that add value to it, the customers' requirements are taken into account when selecting the critical process. Applying risk assessment methods, the critical stage of the certification service was identified, i.e. the process of organizing the examination, which starts from the moment when the certification applicant's documents are received from the expert with a positive evaluation until the moment when applicants are invited to the examination at a specified time.

A working group of three people was created to visualize the current LEEA SpecSC exam organization process: Head, Deputy Head and Examination Expert.

The task of the working group in drawing up the current process was to gather the information needed to create the future situation by setting the time required for each activity (see Table 2).

Table 2. Classification of time categories

Time category	Description
Cycle time (C/L)	The time required to process one applicant's documents during one stage of the process, or the time it takes for the employee to complete all of the steps until the applicant's documents proceed to the next step.
Value-added time	The time it takes to create the value for which the certification applicant is ready to pay.
Flow time	The time it takes for one applicant's case to complete the process or its stage from start to finish, including time between the processes, and time when the certification applicant is waiting for the examination.

The value-added time required for each activity was classified according to the Lean methodology (see Table 3).

Table 3. Classification of time according to the Lean methodology

Time category	Description
Inevitable	The amount of time spent that neither creates value or loss for the customer, but is necessary for the specific activity.
Value-added	The amount of time spent adding value for the customer.
Waste	The amount of time spent that does not add value for the customer.

In order to be able to determine the time of the cycle, the value-added time and the flow time, first the main activities of the LEEA SpecSC exam organization process were identified and the time required for each activity was determined. The current state VSM was created and graphically organized by considering fifteen procedural steps (see Table 4).

Table 4. The main activities of the professional competence assessment process

Activity	Time (min)	Time classification	Process stage
Receiving the applicants' documents from the expert.	30	Inevitable	Receiving the applicants' documents from the expert
Reviewing and selecting cases for initial certification.	10	Inevitable	
Sending the applicant information on the results of the evaluation of the documents and the possibility of receiving the examination program questions.	10	Value-added	
Handing the files to the employee who organizes the exam.	2	Inevitable	
Keeping the files separately until the examination day.	5	Inevitable	Coordinating the examination time with the applicants and the experts
Phoning the applicants to arrange the examination day.	15	Value-added	
Putting the coordinated applicants' files separately.	2	Inevitable	
Phoning the experts to coordinate the examination time.	15	Value-added	
Preparing exam protocols.	15	Inevitable	Preparation of the examination documentation
Preparing documents for handing them to the accountant for invoicing.	15	Inevitable	
Handing the documents to the accountant for invoicing.	5	Inevitable	
Waiting for the accountant to prepare invoices.	15	Waste	
Scanning invoices.	5	Waste	
Sending invoices to the applicants by email.	5	Value-added	
Preparing exam tickets.	15	Value-added	

From the main activities performed in the Table 4, it is obvious that the total time of LEEA SpecSC exam organization process is 164 minutes, inevitable time is 84 minutes, value-added time is 60 minutes and time waste is 20 minutes.

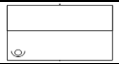
The examination process organized by LEEA SpecSC for one applicant starts from the moment when the expert submits the evaluated applicant's documents to the LEEA SpecSC head for initial certification and finishes with the preparation of the examination tickets on the areas indicated in the applicant's application. As the maximum number of examinees at one time are 8, the LEEA SpecSC employee needs 1312 minutes or 21.8 hours to organize one exam.

According to the internal regulations of LEEA SpecSC, the examination must be arranged within 10 days from the moment when the expert submits the reviewed applicants' documents with a conclusion about their compliance with the requirements for initial certification. The expert receives applicants' files for evaluation twice a week, and only after receiving the expert's conclusion, the LEEA SpecSC employee starts further planning of the examination process. The organization of the examination is generally divided into 5 stages:

(1) informing the applicant;
(2) receiving files from the expert;
(3) processing the received files;
(4) coordinating the exam time;
(5) preparing the examination documentation.

The current state VSM was created according to the standard of Value Stream Mapping using the icons depicted in the glossary of items (see Table 5).

Table 5. Notations of VSM

Notation	Explanation
	Customer, expert
	Manual information flow (document transfer)
	Electronic information flow (electronically transferred information)
C/L	Cycle time (includes inevitable and loss time)
C/T	Value added time
	Actually looking at things
	Opportunity for improvement
	Process

The current state VSM was created and graphically organized (see Figure 1) by considering fifteen procedural steps (see Table 4)

Below the process information explanations, a timeline is drawn that indicates the time containing the flow and value added (see Figure 1).

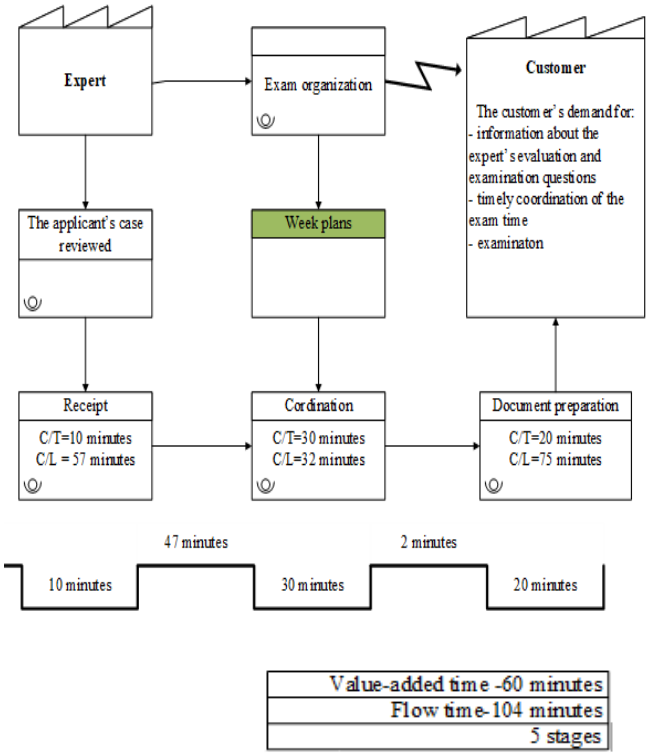


Figure 1. The current state of the professional competence assessment process

From the visualization of the current examination organization process, it is obvious that the customers' main requirements for the implementation of the process are:

(1) obtaining information on the expert's conclusion regarding the applicant's compliance/non-compliance with the certification requirements;
(2) receiving the examination program questions in due time;
(3) timely coordination of the exam time;
(4) receiving the exam tickets according to the certification areas specified in the application.

The visualization of the current examination organization process demonstrates that the value-added time is 60 minutes or 36.6% of the total time of the process, while the flow time is 104 minutes or 63.4% of the total time of the process. In the current examination process organized by LEEA SpecSC there were identified two major failures related to the preparation phase of the documents required for the examination that make up 12.2% of the total process time.

By visualizing the current LEEA SpecSC exam organization process, the authors conclude that arranging one exam with the maximum number of examinees in one group, i.e. 8, requires 21.8 hours or about 3 working days for the LEEA SpecSC employee. Whereas, to organize an examination for one certification applicant requires 2.7 hours for the LEEA SpecSC employee, where 1 hour is the time that adds value for the customer and 20 minutes is the time that does not create added value for the customer. Currently, the examination organization process cannot be ensured within the required deadlines, so the authors

conclude that the total time spent on organizing the exam is too long and it is necessary to take steps to eliminate the identified losses and reduce the overall duration of flow time in the exam organization.

The visualization of the future state

The goal of the future process visualization is to identify the losses, to reduce them and to create an efficient flow of the future process [27].

In describing the future process, the visualization of the current LEEA SpecSC exam organization process identifies several opportunities for improvement that should be taken into consideration in preparing the future process. Opportunities for improvement of the LEEA SpecSC exam organization process are shown in Table 6.

Table 6. Opportunities for improvement

Process stage	Economy of time (min)	Proposals to improve
Receiving the applicant's file from the expert.	5	The expert, prior to handing the file to LEEA SpecSC, informs the applicants about the results of the evaluation of their submitted documents.
Informing the applicant about the possibility of receiving the examination program questions.	5	The examination program questions are given to the certification applicants when they submit the documents for certification.
Receiving the applicant's file from the expert.	57	The expert puts the files in a specially designated place, so that the LEEA SpecSC employee does not have to review the documents already evaluated by the expert.
Coordinating the exam time with both experts and certification applicants.	15	The duration of the next exam is coordinated with the experts on the day of the previous examination.
Preparing the exam documentation.	40	The accountant prepares invoices without the participation of the LEEA SpecSC employee.
Total:	122	

By introducing all of the above improvements, the LEEA SpecSC exam organization process can be shortened by 122 minutes, while also eliminating losses that do not add value to the customer.

The future process preparation is based on the ECRS method, which includes several stages of activities [27]:

(1) Eliminate – to identify and eliminate actions that are unnecessary.
(2) Combine – to clarify the steps necessary for the implementation of the process and to combine them to prevent diversification.
(3) Rearrange – to find the stages of the process whose order of execution or the performer of the process stage can be changed.
(4) Simplify – to look for ways to simplify all the activities that are necessary.

When preparing the future process of LEEA SpecSC exam organization, it is important to eliminate the unnecessary actions and combine the necessary actions, as well as to find the possibilities of changing the responsible persons and simplifying the necessary activities (see Figure 2).

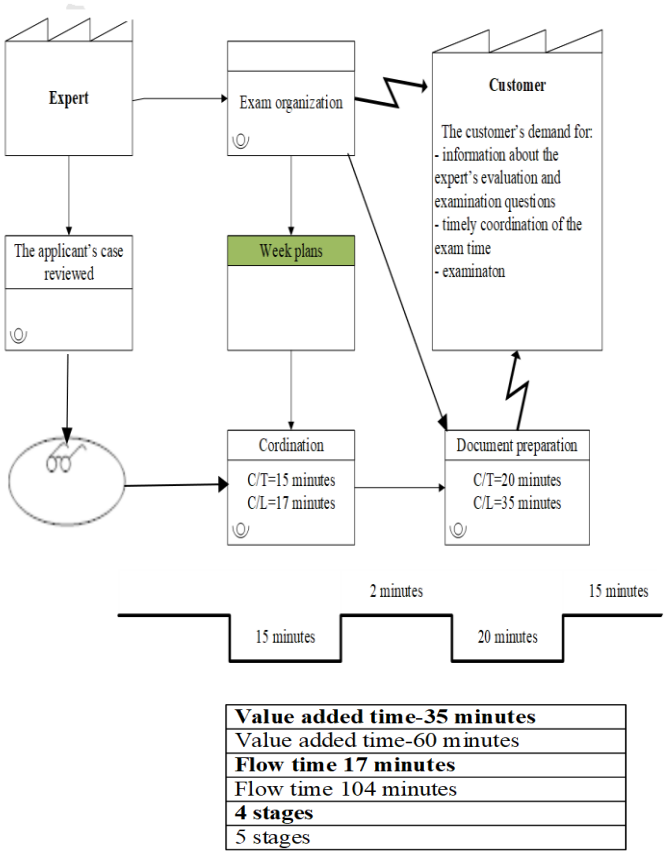


Figure 2. The visualization of the future state

From the future process visualization, it is obvious that the total time of LEEA SpecSC exam organization process has decreased from 164 minutes (or 2.7 hours) to 52 minutes, of which 35 minutes (67%) is value-added time and 17 minutes is the flow time. Losses identified during the preparation of the documentation required for the examination have also been eliminated. In turn, using the ECRS method, a number of significant changes have been made to the LEEA SpecSC exam organization process.

Preparing the future visualization of the LEEA SpecSC exam organization process, the authors conclude that the duration of the current process per applicant could be reduced by about 68%. The time that the LEEA SpecSC employee is currently using to organize one exam is reduced from 21.8 hours to 6.9 hours. Applying the VSM method, opportunities for improvement were discovered, which would not only eliminate the identified losses in the currently implemented LEEA SpecSC exam organization

process, but also provide an opportunity for LEEA SpecSC to organize the examination within the statutory deadlines. In addition to that, the authors conclude that it is recommended to evaluate the causes of the main impact factors related to the competence assessment activities by the certification body in order to obtain information about the main barriers to professional competence assessment in the certification process of persons.

5. CONCLUSIONS AND DISCUSSION

The goal of this article was to introduce the VSM method for description, analysis and finding of suitable improvements within the certification processes of a professional competence assessment.

From the analysis, the authors conclude that the implementation of the Lean approach provides effective ways to improve the performance of processes in different industries, thus helping to enhance the outcomes of many areas besides manufacturing. In order to assess the opportunities for improving the procedures for certification of persons in the future, especially in the field of construction that is related to potential risks to human health and life, it is necessary to identify the role of certification in ensuring compliance of construction specialists' professional competence with the requirements laid down in the industry.

On the basis of the conclusions made from the review of Lean management and VSM results, it could be observed that the professional competence assessment process of construction specialists contains activities which are non-value-added and do not ensure compliance of the professional competence assessment procedure to the requirements laid down in the professional sphere. Accordingly, it is necessary to continue research with an in-depth analysis of the main impact factors related to the competence assessment activities in order to obtain information about the main barriers to professional competence assessment in the certification process of persons.

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