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Inefficiencies in Norwegian small-scale construction, or the problem of too long trucks?

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Abstract

"When the truck arrived at the construction site it could not unload the material because it [the truck] was too long, we had to send it away […], this happens all the time in Oslo where we have to build on very small plots." (Carpenter, Oslo). As the quote illustrates, inefficiencies and resulting low productivity remain a challenge for today's small construction businesses. While the reasons for inefficiencies are not completely understood, various techniques for project planning and control have proven their practical value in mitigating them. Lean construction has been articulated as one of the concepts that can solve inefficiency problems. The national initiative "Lean construction Norway" initiated by government, academia, and industry, seeks to diffuse lean production principles in the construction industry. However, small to medium sized contractors remain largely excluded from the innovative practices. This article sets out to study what a small Norwegian contractor enforcing lean concepts in addressing construction inefficiencies may gain. Ingrained in the concept of muda we exemplify waste related to waiting, overproduction, defects, inventory, motion, over processing, and transporting. We ran a case study in a small industry standard type of residential project executed by a small contractor. Data were collected based on a series of qualitative interviews conducted with the on-site personnel. The findings illustrate a variety of inefficiencies resulting in low productivity. We expect that management inspired by lean principles in conjunction with modern planning methods such as building information modelling may improve project delivery in Norwegian small-scale construction.

Keywords: Muda, lean, SME, residential construction, construction management

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1. Introduction

In contrast to many other industries, the construction industry has not been able to increase its labour productivity over the past four decades. Construction has failed to innovate it's supply chain and is notorious for bad planning [1]. According to a recent study conducted by the research institute SINTEF, Norway's construction labour productivity has not just stagnated, it has declined over time [2]. Scholars argue that constant market pressures, such as having to build cheaper and faster, have had adverse effects on construction productivity [2]. Innovations such as computer aided design, building information modelling, and lean construction have all been hailed as game changers for construction productivity. However, none of these innovations seem so far to have delivered on their promise.

Moreover, construction management researchers have produced a wealth of studies seeking to advance new processes and technologies to improve productivity. Some of these efforts introduce concepts borrowed from other industries such as manufacturing. A prominent example of this is the attempts to apply lean manufacturing ideas in building construction [3]. However, such innovative practices are seldom embraced in practice, and especially small to medium sized construction firms appear to struggle when implementing new ways of doing business. Our article contrasts present-day practice in an industry standard type of project executed by a small construction firm with the ideals of lean manufacturing. This article is yet another attempt to understand, rooted in the realities of our projects, why practitioners have a hard time improving productivity in their projects. The research question asked in this article is: *What are the prospects for curbing non-value adding activities in small-scale Norwegian housing construction?*

To answer this question, we ran a series of interviews in Norwegian residential projects in the Oslo area of Norway. The case projects are industry standard type of construction projects executed by small-scale construction companies. We informed our study by muda, a framework developed for identifying deviations from optimal resource allocation in manufacturing. Muda provides a structured way for identifying and eliminating non-value adding activities in manufacturing. Thus, informing our study in muda provided us the opportunity to identify where concrete improvement in a building project is feasible. Our findings suggest that much of the on-site work suffered from poor planning and coordination. The answer to our research question would seem to be that in almost every aspect of the project, delivery resources were wasted.

Similar to what others have found before us, we find small-scale construction companies to continue struggling with plenty of issues seemingly resolved in the construction management literature. When discussing the findings with the case companies' management, they stated that: "these or similar problems can be observed in most small projects in Norway, which is why we have no problem with you publishing this" (project manager #1). Following up on this research, the company called in an 'emergency' board meeting to discuss the findings presented in this article and implement change in their company. Why small companies continue to overlook inefficiencies in their daily work and how there appears little to no awareness in firms' management of how to improve practice are areas in need of further research.

Researchers may find themselves asking "for whom do we toil?" if none of the discoveries made in project and construction management seem to materialize in industrial practice. How can it be explained that in 2016 in a modern western economy like Norway, where knowledge is widely available through the internet, that construction firms continue to operate seemingly without any managerial concepts? The questions that must be asked are how can we reach out to the industrial communities in need of our work? Are our journals and conferences the right means for disseminating knowledge on how to run construction projects? What can be done to make our research count? Our article is structured as follows: first, we introduce muda and its concepts of waste, second we present the method of our inquiry, third we present the results of the interviews, and last we discuss and conclude our article.

2. Theoretical lens

There is much research reporting from the application of lean manufacturing ideas in the context of building construction. In this article, we apply one of the main concepts of lean manufacturing, namely "Muda", to study industrial practice in a construction project. Muda is a core concept of the Toyota Production System and means "futility; uselessness; wastefulness"[4]. The origins of the concept can be traced back to Henry Ford's work which found waste reduction to be an effective way to increase profitability. Toyota adapted Ford's initial ideas and coined the term muda [5], which is in Japan widely recognized as a reference to a product improvement program or campaign.

Value-added work adds value to a good or product that customers are willing to pay for. Muda consumes more resources than necessary and thus can be viewed as waste [6]. The production system at Toyota works based on systematic and stage wise assessments of whether activities create value or not. By classifying the activities in a building process into these two categories, it becomes possible to take focused action for improving efficiency. After having separated value-adding activities from non-value adding work then a further subdivision is necessary. There exist non-value adding activities that need to be done in order to enable value-adding work. Thus, there exist three categories of activities (1) value adding work; (2) non-value adding work; and (3) waste. According to Taiichi Ohno, the inventor of Toyota's production system, this analytical work will teach people "to see" and challenge their assumptions behind their current processes. There exist seven different types of waste within muda, namely [7]: transportation, inventory, motion, waiting, over-production, over-processing, and defects. The table below presents an attempt to translate these from lean manufacturing to lean construction.

Table 1. Seven "Muda" points

"Muda" points	"Lean Production"	"Lean Construction"
Transportation	Unnecessary movement of materials between production sites, due to bad or lack of planning.	Unnecessary movement of materials on- and off- site, due to bad or lack of planning.
Inventory/ Storing	Too many materials stored longer than necessary, driving costs.	If too many building materials are stored at the building site. It could obstruct the site, lead to damage of materials.
Motion	Unnecessary movement of people, tools, and materials.	Unnecessary motion of materials, tools and workers around the building site.
Waiting	Whenever goods are not in transport or being processed, they are waiting. In traditional processes, a large part of an individual product's life is spent waiting to be worked on.	Stop or waiting time in production.
Over-production	Overproduction is considered the worst muda [8] because it hides and/or generates all the other mudas. Overproduction leads to excess inventory, which then requires the expenditure of resources on storage space and preservation, activities that do not benefit the customer.	Production of goods before they are needed creating waste other places. Also 'scope creep', producing something not asked for by a client.
Over-processing	Over-processing occurs any time more work is done on a piece than is required by the customer. This also includes using components that are more precise, complex, of higher quality or more expensive than required.	Construction work of poor value for the customer (too complex, wrong qualities etc.)
Defects	Whenever defects occur, extra costs are incurred reworking the part, rescheduling production, etc. This results in labor costs, more time in the "Work-in-progress".	Deviation resulting in a customer not being satisfied with the result of the product. Unnecessary re-work.

3. Method

A case study approach has been selected for exploring whether inefficiencies in construction projects can be explained based on muda. A case study was considered appropriate since it allows for exploring "sticky practice based problems where the experience of the actors are important and the context of the action is critical" [p.370, 8]. Moreover, a case study allows for understanding the process whereby the construction work influences and is influenced by the context [9]. We decided to conduct our case study on projects executed by a Norwegian medium sized contractor and three sub-contractors. Most of the sites were small and tiny detached and semidetached projects. Most of the projects are located near the center of Oslo. These developments were considered a suitable case for our study to examine the seven methods of muda since they were industry standard type of projects. Our data was collected through semi-structured interviews with thirteen construction professionals, aiming to gain an understanding of the phenomenon by asking those experiencing it. Using interviews as the means of data collection served as a way to access the interpretations of informants in the field [10]. The intention was to interview key construction actors to examine the reasons for inefficiencies. The interviews were conducted in February 2015, at a point in time when the

design and construction had not been finalized. Table 2 provides an overview of the interviews conducted. Interview guides were designed based on muda. Informed consent was sought in advance of all conducted interviews. All interviews were voice recorded with a Olympus LS-12 Linear PCM recorder, transcribed, and coded by using the qualitative data analysis software NVivo10. Categories were derived from the data assigning nodes to notions, which could be related to the core concepts of the muda. An overview of the interviewees is presented in table 2.

Table 2. Interviews conducted.

Professional role	Construction site location	Interview technique
Carpenter # 1	Oslo	Face-to face
Carpenter # 2	Akershus	Face-to face
Carpenter # 3	Akershus	Face-to face
Carpenter # 4	Akershus	Face-to face
Carpenter # 5	Akershus	Face-to face
Carpenter # 6	Akershus	Face-to face
Carpenter # 7	Akershus	Face-to face
Sub Contractor # 1	Akershus	Face-to face
Sub Contractor # 2	Akershus	Face-to face
Sub Contractor # 3	Akershus	Face-to face
Sub contractor # 4	Buskerud	Face-to face
Sub contractor # 5	Buskerud	Face-to face
Project Manager # 1	Møre og Romsdal	Face-to face

4. Results

The analysis part of the paper is structured as follows. After identifying data on the seven types of waste in the case project, the analysis followed the structure suggested by muda and presented in chapter 2. We have divided the analysis part into the seven points of muda: Transportation, Inventory (Storing), Motion, Waiting, Over-processing, Over-production and Defects.

Transportation. During interviews, it was revealed that the large trucks did not reach the tiny construction sites and the consequences was that materials had to be loaded into smaller trucks and transported to the site. Carpenter #1: "When the truck arrived it could not reach the site because it was too long. We had to send him to the parking at our main office, were he unloaded the truck. We had to leave the site because no materials arrived." Carpenter #2: "Yes it (the truck) was to long, yes. It`s the pre-cut I assume. Because he has a very long truck, therefore he could not pass the steep curves and did not reach the site…This happens all the time in Oslo. There are many projects done on tiny spaces. We have experienced that they (the trucks) have left the construction materials on the road". Other encountered problems seem to be a result of poor planned transportation and logistics on the construction site, for instance parking of cars as sub-contractor #1 points out: "Parking has been difficult. There are very many actors on site at the same time, and parking has not been taken into the planning. Many have received a ticket" Sub-contractor #5 continues: "If cars and lorries are waiting, the logistics does not work and that is serious."

Inventory/ (Storing). For a site to be safe, it is important to plan the delivery of construction materials and their storage. Usually on-site storage areas are limited and then ordering the materials to arrive on site in the right sequence becomes important. The construction materials must be available just in time and no earlier. Carpenter #3: "It is the matter of float etc. We usually receive all the materials for the houses together. If we could receive materials when we need them it would be much easier." Carpenter #5: "It happens often that materials are on site long before their actual use, changes occur, and the materials arrive before the carpentry of the house has started. Then all the materials are just waiting." "Then the materials are […] in the way" (carpenter #6). In addition, carpenter #3 points out: "I have experienced that materials for the first floor arrive early in the week, and then later in the same week materials for the second floor arrive. Then these materials have to be stored for weeks". Carpenter #3 points out: "I have experienced

that the support system to the first story has arrived, and then immediately after the support system for the second story and the trusses for the roof arrive the same week. This is because of the building permit being due in week 3 and we are delayed to week 5-6 and the materials are not rebooked." Using blown-in insulation was pointed out as an alternative, saving space on site. Sub-contractor #2: "It is fast, it is faster than insulating the old way. You avoid having many packages of insulation lying around in the building, which you would have to move two or three times to do your work!". Carpenter #2 would prefer the blown-in insulation, too: "It would be great to get rid of that. We have to manhandle the insulation many times before even putting it into the wall […] It would be much easier if we could just blow the insulation into the walls, without storing it inside the house and moving it around".

Motion. The movement of construction workers and materials is a large part of the building process. Lack of continuity and float in the building process can lead to production being stalled and will result in poorer economic project results. The interviews with the carpenter teams revealed this, carpenter #4: "Being able to work at one place and finish the job, not being moved from place to place and do a little bit here and a little bit there…" Carpenter #1 points out a persistent problem: "Excavations are always a problem. If they have not done everything that should have been done before we start, […]. If they have to come again and move into the site, then it has large consequences, everything that is stored outside has to be moved around."

Waiting. Delays and bad planning of the building process result in production delays, too. This can lead to a loss in the contractors' earnings. Carpenter #7 points out that it takes time to wait for others to be finished: "Some periods we have to wait many days before we can start". He points out that waiting occurs often between the building of two houses: "It is a waiting period between building two houses. To make this period as small as possible, efficient planning is necessary." Carpenter #2, when asked where in the building-process delays occur, emphasizes this: "…and lack of materials happens often. Yes, really often […].", and he points out the reason: "it is the ordering that is wrong, for instance too small… quantities. So then we have to reorder, and then it takes some time before we receive the materials, and it is too late". Carpenter #1 points out what happens: "Either we are sitting on our ass, or we go home, or we call the office and ask if there is something else we could do". In a construction site, many craftsmen are working together, which could result in collisions between the different trades. Carpenter #6 points out: "Yes, it has been a frequent problem. You have 20 people working on the same floor. You want to only put a molding on one of the walls, then it may take up to two hours because there are people everywhere." Carpenter #6 and carpenter #5 give another example: "…when the tiler works while you are mounting boards on the indoor walls, then he (the tiler) should tile the floor of the entrance room. It is not possible to do it, and we cannot walk in and out because he is in the way, he takes the entire floor". Carpenter #6: "Then you have to give up working inside, and you have to find something else to do".

Over-production. In the building industry, it is not so much over-production as bad planning of material deliveries which could lead to excess storage which in the "LEAN construction" could be over-production. Carpenter #2 gives an example of when the windows for a house have arrived too early: "Like the windows there. He (the carpenter), worked with the timber frames on the first floor, so I thought it wasn`t for him, so the driver drove around and looked for where to deliver them. ….So they are still stored inside the house waiting to be installed. And there they have been since before Christmas".

Over-processing. A building project should create value for the customer, and then it is important to satisfy the customer's needs. If the customer is not satisfied, the candidates agreed that the problem was due to inaccurate drawings. In the question of how the building process of the medium sized contractor had been, carpenter #2 points out: "There has been some lack of drawings with measurements for a period. (….) and we have had to use the calculator. It is not supposed to be like that". Deficient drawings are also pointed out by Carpenter #5 and #6: "The drawings are sometimes unclear, and they are not updated to the newest format or are inaccurate." Carpenter #6 points out: "There are often revisions of the drawings….and it occurs often that we are not given the latest version. For instance, they move a door, or change the opening direction of the door, such types of things. If we should move a door from one side of the wall to the other side of the wall, and we have not received the revision…. The architect could be better there." The candidate also points out that there was a problem with the technical details, and in many interviews, it was mentioned that each carpenter team should have a detailed archive folder. These are not updated and therefore not in use, Carpenter #2 points out this: "….I believe that not everyone has received it, (detailed archive folder), and therefore several things are done different. And also, many things are missing from the detailed archive

folder….” The use of a not updated detail folder could lead to problems: “We had tried to explore a little bit with using building foam around the windows. So we did that, and it was not good enough for him, (the customer), because he had read in the description. Then we had to cut out all the building-foam and do it like the description pointed out”, (carpenter #5). There seems consensus that foreign labor and related communication problems may lead to major challenges, as sub-contractor #3 points out: “We have made big mistakes due to language problems during the years”. “They (foreign workers) know everything, even if you ask them. Yes, they can everything…. In the end they don’t do it the right way” (carpenter #1). “If one of them can speak Norwegian, then it is fine. If we talk with one who neither speaks Norwegian nor English and only says “yes”, and then he does the job, it ends up wrong.” (carpenter #4). “They say, “Yes, yes I fix”, “No problem we fix”. Then it ends up wrong” (carpenter #2). Sub-contractor #1 gives an example where a foreign carpenter placed the water installations: “We arrived at the site, they had moved the water installations inside the wall and screwed on the plasterboard, and the pipes were hidden for the plumber. Didn`t we have some pipes here…?”

Defects. Bad solutions, carelessness and sloppiness during the building period may lead to damages and defects in the building. Accidents happen, but if the same mistakes repeat, it is necessary to find the reason. During the interviews, different causes leading to defects have been identified. Sub-contractor #4 is asked to move a temporary staircase in one of the houses and he points out: “Often the surrounding walls are painted. One single man is supposed to move the temporary staircase that is there. You cannot just start to tear it down, because it is nailed with 4 nails, so you have to move the whole staircase. And the weight is over 100 kg. One person is supposed to move it down, without damaging the walls, and that is a large problem.” The fittings between the concrete walls and roof are mentioned by Project Manager #1: “And then we have impossible solutions, and I don`t understand why the carpenters should accept that. For instance, the molding between concrete walls and the roofs. A joint like that is cracking anyway.”

5. Discussion

All seven forms of non-value adding activity were present in the on-site construction of the projects. All muda categories, ranging from inefficiencies related to the transportation of goods to defects, were evident in the case study. Bertelsen (2003) argued that “construction is […] a complex, nonlinear and dynamic phenomenon, which often exists on the edge of chaos” [14]. Our findings are in line with what Bertelsen (2003) suggests, that indeed some of the identified practices would qualify as outright chaotic. Among the reasons for this are bad logistics, a lack of management, inter-cultural and language problems, tight schedules and poor technical solutions and drawings. That construction projects “suffer from waste manifested in waiting time for crews, rework, unnecessary movement and handling of materials, unused inventories of workspaces and materials, etc.” has long been known and our findings once more confirm this [13]. Twenty years ago, Koskela has attempted to quantify waste in building projects and estimated that construction workers spend approximately 2/3 of their total time working on non-value adding activities [15]. This seems still to be the case in Norwegian small case construction.

At least in the cases presented here, none of the powerful planning and control systems developed by the construction management communities seem to have been at use. Thus, neither lean construction nor classical project management inspired project controls seem to have found their way into this part of the construction industry. This is a somewhat discouraging finding for construction management researchers. The fundamental question arising from this is (in the authors’ view): for whom do we toil? Project management and lean production techniques have been around for so long that it becomes inconceivable why practitioners continue to ignore the available knowledge. The contribution of our article is that we show how practitioners also in 2016 continue to work seemingly without appropriate project controls. Further, we point to a quite fundamental question for construction management scholars, namely, do we need new and better ways of diffusing knowledge about project controls? How can we better reach out to the practitioners in need for the ideas generated in our research community?

7. Conclusion

Based on the seven muda points in lean manufacturing, the research question asked in this article was: "What are the prospects for curbing non-value adding activities in small-scale Norwegian housing construction?" We can see that a lack of planning was the main problem in the project. It is especially important to make a detailed plan of the transport of construction

materials to the site. When materials arrive too late the carpenters have to wait, when too many materials arrive early they fill up the site and the craftsmen have to move the materials around while they do their work. Moreover, it is very important that there are not too many craftsmen in the building at the same time. Blowing insulation is advantageous, because it saves space and frees up time for the carpenters. All of the aforementioned inefficiencies could be prevented by making use of the available construction management knowledge. Why firms in 2016 operating in Norway continue to struggle with planning their work is hard to comprehend. The main learning of this article is that apparently none of the known project planning and control systems developed over the years seem to be applied in practice. We conclude that we may need a different dissemination approach for our research findings or otherwise the problem of "too long trucks" will persist. A possible solution to the problem of the too long trucks would be to use shorter trucks.

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