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On the Necessity for Identifying Waste in Knowledge Work Dominated Projects: A Case Study from Oil & Gas-Related Product Development Projects

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Abstract. Within the field of management, knowledge management (KM) enables the generation, sharing, utilization and management of knowledge and information. In order to optimize the processes of KM, Lean thinking and tools can contribute to identifying and eliminating or reducing waste or activities and/or actions that disrupt or do not add value to the information and knowledge generation that ultimately returns value to the end user. Projects, such as product development projects (PDPs), are in general knowledge work (KW) dominated. This manuscript presents an exploratory case study, conducted at a company providing oil & gas operations' services in Norway. The study examines the initial phases of their PDPs, where KM and KW play a more significant role, as information and knowledge are often limited, and uncertainty is high. It is hypothesized that waste in the early phases causes subsequent underperformance in the overall project. This manuscript first elaborates the notion of waste in knowledge work dominated projects from a theoretical perspective. Furthermore, a mixed-method approach was applied, while a survey and semi-structured interviews were conducted. Finally, the Gioia methodology is utilized to process the findings and present a conceptual framework to support KM as a means to prevent or minimize waste in KW-dominated projects.

Keywords: Lean thinking, Lean knowledge work, product development, waste management

1 Introduction

Lean thinking has become a focal business or organizational philosophy for many companies over the last few decades [1]. It is proven to be a significantly important business philosophy which emphasizes customer value by systematically reducing or eliminating overburden, variation and waste or non-value added activities (NVA) [2]. However, implementing Lean within knowledge work (KW) dominated projects, such as product development projects (PDPs), requires adaptation, due to the nature of the projects [3], which are characterized by several KW-related areas, such as integration management, scope management, time management, cost management, quality management, etc. [4]. In contrast to a manufacturing environment or an assembly line, which is more repetitive and materialistic, KW is not as repetitive and capable of being defined unambiguously with relative certainty [5]. Hence, understanding the field of KW-related waste is deemed necessary, to potentially enhance performance in the overall project.

The purpose of this study is to identify and understand how waste or NVA and actions in front-end phases or early stages of KW-dominated projects can impact the performance of the overall project. Accordingly, an exploratory case study is conducted at an engineering contractor company providing oil & gas operations' services in Norway. PDPs in one of their design engineering departments is chosen for the purpose of this study. A mixed-method approach is chosen, with a survey in the form of a self-completion questionnaire being developed and conducted, based on a literature review. Furthermore, semi-structured interviews are carried out to further investigate the findings from the survey, which statistically illustrate a low level of operational waste in their PDPs in general. However, findings and analysis from the interviews reveal another dimension of waste which can have a considerable effect on the performance and potentially the outcome of their projects.

2 Literature Study

The philosophy of Lean relies heavily on employee-driven and systematic identification and removal of waste; this is believed to be a fundamental and critical aspect to understand, in order to effectively target and apply relevant Lean tools and successfully become Lean [1, 6]. Since its origin in the automobile manufacturing industry, Lean has been widely recognized, studied, adapted and implemented in various industries, in both the private and public sectors [7, 8]. However, applying Lean principles and approaches to KW-dominated projects or environments, has proven remarkably challenging, due to their differences from a manufacturing environment (Table 1) [3, 9]. Compared to an assembly line, which is more materialistic and repetitive, knowledge management and KW involves human expertise and judgement that depend heavily on tacit knowledge and data and information, to generate and utilize knowledge [5].

Table 1. Lean principles in manufacturing vs knowledge work, adapted from [9]

Lean principles	Manufacturing	Knowledge work
Value	Visible at each step, defined goal	Harder to see/define, emergent goals/deliveries/requirements
Value stream	Parts and materials	Data, information and knowledge
Flow	Iterations are waste	(Un)planned iterations and/or ad hoc approaches must be efficient
Pull	Driven by takt time	Driven by needs of enterprise and/or customer/end-user
Perfection	Process repeatable without errors	Process enables enterprise improvement

From a macroscopic perspective, researchers equate knowledge with professional intellect, which in organizations centres around several contexts or knowledge layers, such as *know-what*, *know-how*, *know-why* and *know-with* [10]. Accordingly, the information processing system relative to these layers can be analogously and holistically compared to a value-flow model of a manufacturing system [11]. As mentioned, in manufacturing, physical goods flow through the production system; in KW-dominated projects, this hardware is replaced by information and knowledge in its various forms (Fig. 1).

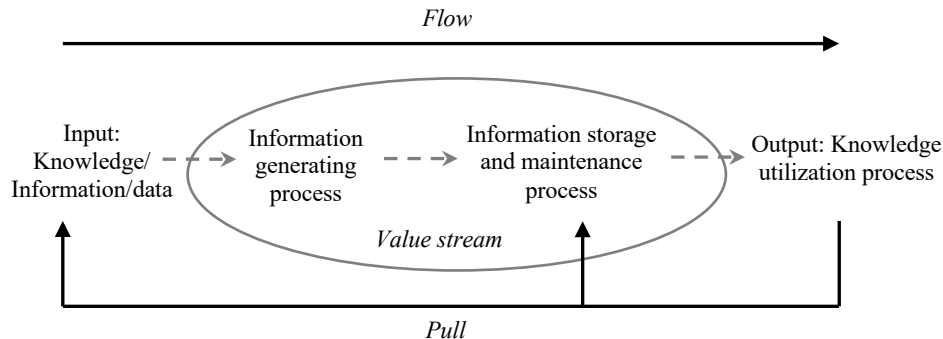


Fig. 1. Information processing system, adapted from [11]

Projects, such as PDPs, are in general dynamic, time restricted, multi-disciplinary, goal- and customer-oriented, communication-intensive and KW-dominated, especially in the initial or front-end phases, which to a greater extent are comprised of planning, analysis, creativity, ideation, design processes, etc., often within uncertain conditions with limited information [12, 13]. When describing waste within such environments, the traditional waste categories from manufacturing are also analogously applied when managing Lean in the knowledge-work paradigm. However, due to its complexity, the set of categories cannot be considered all-inclusive [14]. Authors such as [9, 12, 14-19] address this issue by reformulating, adapting and supplementing the traditional operational waste (OW) categories in a PDP environment (Table 2). Due to the complex nature of this environment, interdependency and the formation of a complex causal network between the OW categories must be taken into account (Fig. 2) [14].

Table 2. Operational waste categories

Waste	Description
Over-production	Producing and/or distributing unnecessary and superfluous information (e.g. extra features, documents, design etc..).
Over-processing	Unnecessary processing of information/completion of tasks beyond what is required in the process
Defect	Defective information which deviates from the standards of its purpose or from the customers expectation; it entails the activities creating and using defective outputs / incomplete or incorrect information for/in the process.
Correcting	Correcting relates to the effort involved in re-doing, repairing or reworking information.
Transportation	Inefficient or unnecessary transmittal/movement/communication of information, between people, organizations, IT systems, disciplines etc.
Motion	In contrast to transportation, motion relates to unnecessary human movement (physically) to acquire needed information.
Inventory	Build-up or stockpiling of information (e.g. raw, in-process and/or processed features and material, such as prototypes, that is not being used).
Waiting/Delays	Waiting is when the value-creating processes are standing still; as a result, the value stream is considered “non-flowing”, this can be due to the lack of necessary inputs, resources, controls, approvals etc., causing delays.

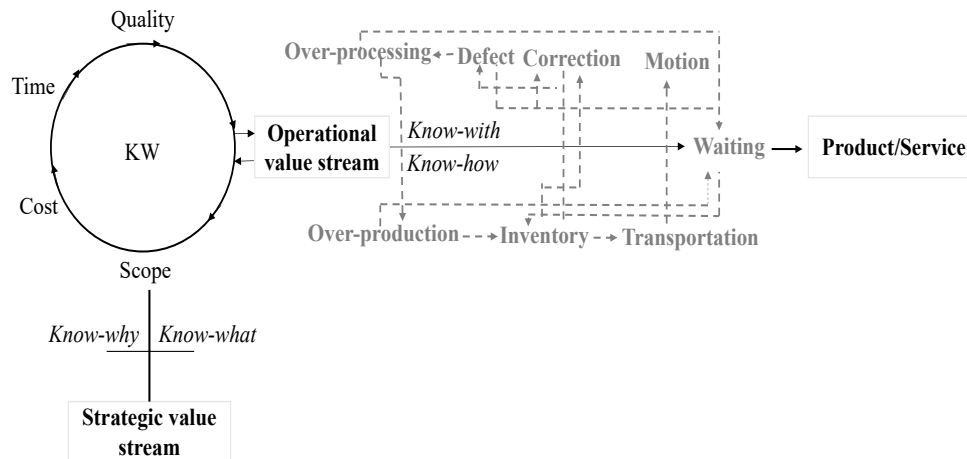


Fig. 2. Conceptual illustration of value streams and waste in KW dominated projects, adapted from [14, 16, 17]

3 Methodology

As the object is to explore and understand a complicated phenomenon, the philosophical perspective of this study is considered to be an exploratory case study [20]. Case study research is concerned with the complexity and particular nature of the case in question. Such studies typically aim to answer “how” and “why” questions, and in essence explore and investigate contemporary real-life phenomena [21]. The research method is comprised of a survey or self-completion questionnaire and semi-structured interviews.

3.1 Lean maturity assessment

A survey was developed, in order to assess the department’s PDP Lean maturity. The survey was administered to 13 engineers in the department as a self-completion questionnaire. The multicriteria-based matrix consisted of five assessment levels and 37 questions related to commonly identified NVA in PDPs [22].

3.2 Gioia methodology and 5 whys analysis

For the 5 whys root-cause analysis, semi-structured interviews were chosen, in order to encourage the interviewees to speak freely. A total of four interviewees participated individually in the analysis. Furthermore, the qualitative structuring and analysis of the findings is based on the adaptation and application of the Gioia methodology, which offers a systematic approach to new concept development and grounded theory articulation [23].

4 Case Study Background

The selected case study company supplies mission-critical products and services for the global oil and gas industry. This study investigates a PD design engineering department that provides services in the Nordic region. The department's main role is to support their customers, by developing, upgrading and maintaining the company's installed products and services, as well as providing technical studies and lifetime extension support. Fig. 3 provides a broad illustration of their PDP process. As Fig. 3 illustrates, projects experience high uncertainty, complexity and flexibility regarding decision-making in the initial phases, while these decrease as the project develops and information increases. In order to reduce uncertainty, risk and waste in the early stages, the process of KM is seen as an important and central field of their management.

When PDPs reach the implementation phase, they have been executed using the traditional definitions of waste. However, a hypothesis is that the experienced OW or non-value-added activities (NVA) in their implementation phase are results of root causes developed in the early stages of the PDPs. If these activities and root causes are not analysed, the resulting decentralized strategic decisions may continue to produce operational challenges. There is a need to identify and define these in a new conceptual framework, which can be purposed as a tool that contributes to increased value creation and better KM in the early stages.

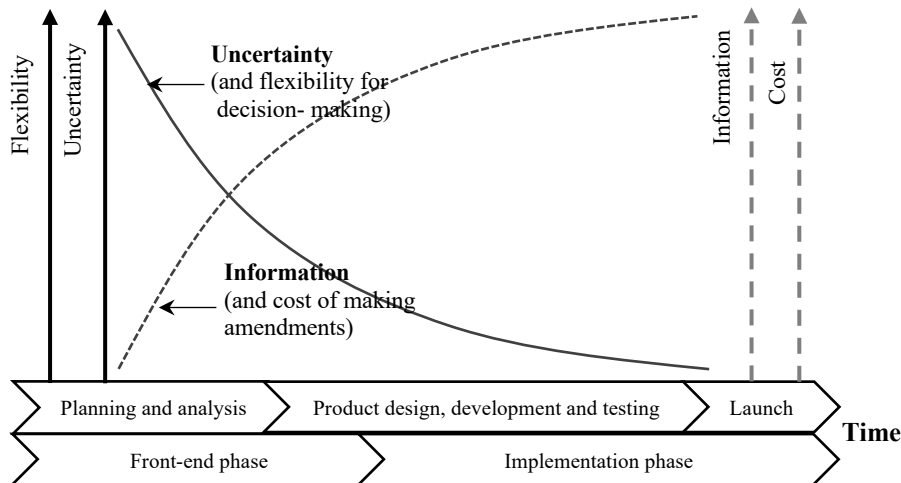


Fig. 3. Illustration of PD process, adapted from [22, 24, 25]

5 Data Collection and Findings

5.1 Lean maturity assessment

Considering the average Lean maturity index of 3.8 (dotted line in Fig. 4), the individual maturity scores of Waiting, Transportation, Over-processing, Correction and Defect are below and interpreted as those that should be further investigated. However, statistically, the results illustrate overall low variation between the given categories and high Lean maturity in their projects.

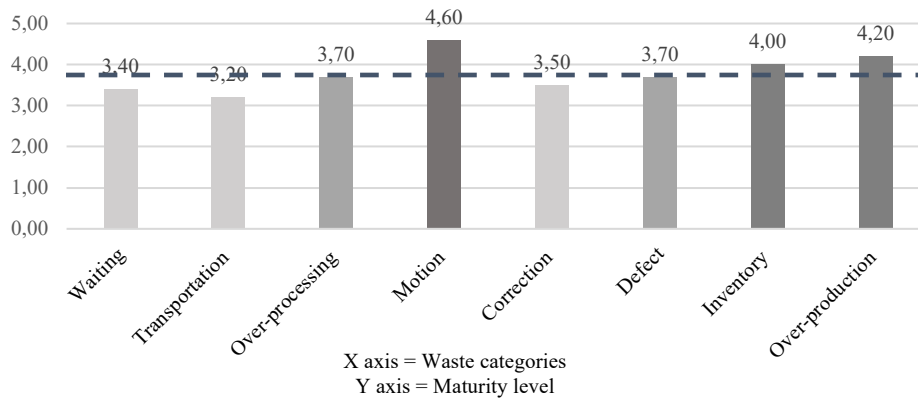


Fig. 4. OW in PDPs [22]

5.2 Gioia methodology and 5 whys analysis

In order to limit the scope of this study and fully test and simulate the presented methodology, *waiting due to unavailable information* is chosen for further root-cause analysis. This is based on the perception of a complex causal network, where most of the other types of OW ultimately cause some form of waiting. The analysis of root causes presents three orders of analysis, with 1st order analysis presenting a selected portion of root causes that were recurring in all interviews. Furthermore, 2nd order analysis provides a summarized interpretation and description of these. Finally, 3rd order analysis tries to categorize the given descriptions to triangulate and assess whether they are, for instance, related to culture, system, process, management, etc. (Table 3).

Table 3 Analysis of root causes

1 st order analysis: Root causes from 5 whys analysis	2 nd order analysis	3 rd order analysis
<ul style="list-style-type: none"> Poor capturing of technical requirements/needs, due to lack of expertise/knowledge in initial phases Details relative to technical changes are not considered when defining the product and project scope Planning with minimum required resources based on poorly captured requirements Lack of experience and understanding of tasks and alignment of disciplinary tasks when making decisions Poor capturing of needed knowledge, leading to coordination and requirement of additional resource capacity and knowledge from disciplines abroad 	Managers, customers and/or project participants operating blindly and making strategic decisions without the right information, knowledge, expertise etc., regarding the technical and/or operational aspect of the project and product scope	Lack of operational/technical planning

<ul style="list-style-type: none"> • Poor project/product documentation leading to information hunting • Poor project/product documentation, due to no best-practice guidelines • Poor alignment of entities/disciplines in initial phases causes many targets instead of a common one during the project • Diluted and/or miscommunication of information causing different interpretation of needs or requirements • Multiple people handling the information and not documenting well 	<p>Lack of management, handling, documentation, communication, etc., of existing and/or new information/knowledge</p>	<p>Lack of/poor information management</p>
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6 Discussion and Conclusion

The findings from the Lean maturity assessment indicate a high level of maturity in the department's PDPs. However, when exploring and analysing Waiting, there are some human activities, actions and/or conditions that are revealed as strategic waste (Fig. 2), which have operational repercussions. From interviews and Table 3, interpreted summarization and categorization for the identified root causes indicate lack of operational and technical knowledge, expertise, information, understanding, etc., among managers and customers, who are more strategically involved and influential regarding decisions in the initial phases of their projects. Arguably, the knowledge layers of "know-why" and "know-what" relative to the project scope are emphasized more than "know-how" and "know-with" relative to the product scope. This causes poor capturing of technical or operational requirements or needs of the design engineers, providing them with a limited product scope that must be developed ad hoc. Another dimension of root cause seems to be a lack of routines, processes or systems for the management, handling, documentation, communication, etc. of shared information in the project. From Fig. 2, these actions, conditions or activities can be considered to be strategic waste (SW).

Accordingly, there is potential for improvement in the early stages that can contribute to improving the management of generating and capturing the necessary knowledge to a greater extent. This study presents a methodological framework to assess Lean maturity and identify waste and root causes in knowledge work dominated projects. A case study was conducted, in order to explore a PDP environment in an oil & gas company, to simulate the implementation of the methodology. However, the study provides a rather isolated and unilateral perspective of waste and its root causes in a highly interrelating and causal network of OW categories. Hence, further study will explore the application of the presented methodology and the notion of SW in other KW-dominated projects or environments, such as in public sector services, law enforcement, criminal cases, strategic management processes, etc. The interrelating causal network of OW and SW will also be further explored.

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