USAGE OF MANAGEMENT PRINCIPLES IN MACHINE AND IT INDUSTRY AND THEIR CORRELATION

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Abstract: Certainly, in recent times, various management principles have been introduced across different fields. Management, regarded as a social science focusing on organization and administration, is broadly utilized across various sectors. Similarly, every domain has its unique management principles implemented in daily operations. However, these principles share common foundations, adapted to suit their specific intended purposes. This thesis elaborates management principles that are actively used in the machine and IT industry. These two industries are also complementary and use a combination of the same or similar principles with both industries. Similarity of management principles in both industries was determined, research was done on their real practical usage, as well as correlation between them.
Keywords: management principles, machine industry, IT industry

1. INTRODUCTION
Management is the process of planning and organizing the resources and activities of a business to achieve specific goals in the most efficient and effective way possible. A fundamental goal of management is to create value for the end user by helping people to be more productive and creative with shared strengths (S. Magretta, 2012). Efficiency in management refers to the correct completion of tasks at the lowest possible cost. Effectiveness in management refers to the completion of tasks within specified time frame to obtain tangible final results. Management in the machine industry involves the study of the performance of machines in addition to humans. The companies employ specialists who take care of keeping the machines in good working condition and ensuring the quality of their production, as well as specialists who organize and monitor the entire production process (R. J. Thomas, 1994). Project management in the IT industry is also an important part of software development, for organizations that rely on third-party software development (the development is done by external companies) as well as for those whose software is developed in-house. To ensure successful project management for managers responsible for software development, numerous research studies have been conducted in an attempt to determine the factors that lead to successful software project management (J. M. a. W. M. E. Verner, 2005). As time passed and research was conducted, it became evident that some of the management principles used in the IT industry can also be applied in the machine industry. For an extended period, traditional management approaches were utilized due to the inherent nature of the work, with the automated principles remaining unused.

In conclusion, this research demonstrated that the machine industry can benefit from adopting specific work methodologies and incorporating structured frameworks. These approached will enhance team organization and improve the management of work processes. In the continuation of the paper, alongside managerial principles partially or fully implemented in the machine and IT industry the study presents research findings examining the practical adoption of work organization methodologies within the machine industry. It explores whether employees genuinely embrace structured work environments or still prefer the longstanding traditional management methods that do not result in high employee satisfaction. The research indicates that more than 90% of employees in IT companies currently employ specific modern management principles and tools to organize their work processes.

2. MANAGEMENT IN THE MACHINE INDUSTRY

One of the most used and developed methodologies in the machine industry is Industry 4.0. It provides new paradigms for industrial management of small and medium enterprises. Supported by a growing number of new technologies, of emerging technologies, this idea has been proven to be more adaptable and cost-effective compared to conventional enterprise information systems like ERP and MES. Papers are categorized using a novel framework that enables the identification of performance goals, necessary managerial skills, and the specific array of technologies for each chosen scenario. Research shows that small and medium-sized enterprises do not use all the resources for the implementation of Industry 4.0 and are often limited to the adoption of Cloud Computing and the Internet of Things (D. C. Morten Bakke, 2023). Research also emphasizes that small and medium-sized enterprises have adopted Industry 4.0 concepts only to monitor industrial processes and there are still no real applications in the area of production planning itself. A review of the literature shows that reported Industry 4.0 projects in small and medium-sized enterprises are cost-driven and there is still no evidence of real business model transformation. Industry 4.0, part of the fourth industrial revolution, presents a significant and invaluable chance to foster innovation in both social and technological realms. Cutting-edge cyber-physical systems and associated technology architectures have been developed, promising substantial enhancements in a company's productivity and innovation capabilities (M. F. a. M. P. Mubarak, 2020). It also significantly shortens product life cycles and requires an acceleration of the pace of innovation. The vision of Industry 4.0 emphasizes global networks of machines in smart factory settings capable of autonomous information exchange and mutual control (B. C. E. E. A. a. G. P. Tjahjono, 2017). A critical challenge that firms face in managing open innovation is trust among stakeholders. Digital trust, achieved through Industry 4.0 technologies, can play a key role in promoting open innovation.

Industrial management, a field within engineering, enables the development of management systems by integrating diverse engineering processes. It encompasses industrial design, construction, and the application of scientific and engineering principles to enhance industrial infrastructure and processes (H. Fayol, 2017). Industrial management focuses on the management of industrial processes. Industrial managers are accountable for ensuring the optimal interaction of the essential components known as the 4M: Manpower, Material, Machinery, and Methods, all of which are indispensable for any organization. Commonly employed techniques for organizing in mechanical engineering include: Industry 4.0, MACHINE-TO-MACHINE communication, Quality management, human resources management, top management support, technology management and strategic management (S. a. R. G. S. Ahmad, 2003), Lean, Six Sigma and Waterfall methodology.

3. MACHINE TO MACHINE COMMUNICATION (M2M)

Machine-to-machine (M2M) communications are evolving to function independently, facilitating connections between the Internet cyber world and physical systems. This technological landscape consists of wireless infrastructure linked to the cloud and a network of large devices. Various technologies are integrated into real-world applications to enhance the foundational comprehension and engineering expertise in this emerging field of communication and network technology (K.-C. a. S.-Y. L. Chen, 2014). Currently, there is widespread utilization of internet and mobile communications, Internet of Things (IoTs), and cyber-physical systems. These technologies are merging information communication technology with everyday life. By deploying a large amount of machines that are typically wireless devices such as sensors, it is anticipated to greatly enhance human life. Specifically, the implementation of autonomous machine-to-machine communications with wireless capabilities is paving the way for a novel frontier in wireless communications and networking (S. a. R. G. S. Ahmad, 2003). There are numerous technological milestones and research opportunities to achieve wireless machine-to-machine (M2M) communication which will aid in organizing work for humans. M2M embodies cutting-edge technologies for seamless machine-to-machine communication, presenting ongoing intellectual and engineering challenges. As an emerging technology, M2M systems hold significant promise. M2M communication plays a vital role in enhancing the contemporary and future aspects of human life within the machine industry. M2M involves direct communication between devices utilizing various communication channels, encompassing both wired and wireless methods (GD, 2008). Recent developments in machine-to-machine communications have shifted towards a network system that transfers data to individual devices. The global proliferation of IP networks has facilitated quicker and more efficient machine-to-machine communication, leading to reduced energy consumption (HowStuffWorks.com, 2008). M2M serves as a method for managing machines, which further simplifies the manager's tasks in coordinating production process.

4. MANAGEMENT IN THE IT INDUSTRY

The IT industry is among the pioneers in adopting diverse management practices. Traditional management approaches have been replaced by agile methodologies, which developers tailor to their requirements and abilities. These methodologies have evolved over the years and are increasingly implemented in practical settings. Software

engineering is a profession reliant on extensive knowledge, and the management of this knowledge has been a focal point of interest for a long time. Many empirical studies in software engineering delve into and analyze concepts, key discoveries, and the research techniques used. A total of 762 discoveries were recognized, out of which 68 pertained to the industrial setting. Among these, 29 were empirical research studies, and 39 were reports detailing lessons learned. Over half of the empirical studies took the form of case studies (F. O. a. T. D. Bjornson, 2008). In software organizations, the most valuable assets are not physical infrastructure like plants or machines, but rather the knowledge possessed by their employees. The software engineering field has acknowledged the necessity for knowledge management rooted in established disciplines like cognitive science, ergonomics, and management. With the continuous evolution of software engineering, there is a growing requirement for results that are empirically validated. In software engineering, a recent trend emphasizes evidence-based practices. Software management raises three fundamental questions (HowStuffWorks.com, 2008):

1. What key knowledge management principles are investigated in the realm of software engineering?
2. What are the primary discoveries made in knowledge management within software engineering?
3. What methodologies have been employed in the field's research efforts thus far?

Research conducted in numerous large and medium-sized companies indicates that agile methodologies are widely employed (Conforto, 2014). According to detailed case studies, specific Scrum and eXtreme Programming (XP) practices within Agile methodologies have proven effective in mitigating communication, coordination, and control challenges in global software development (GSD). These practices contribute to reducing time, geographic, and sociocultural disparities in GSD projects (Holmstrom, 2006). Recent findings show that certain systems development organizations are adopting a hybrid approach, integrating both agile and traditional methods to capitalize on their respective advantages. Besides agile methodologies, companies are also incorporating Application for Project Management (APM) tools into their practices. Similar to agile methodologies, APM also follows its unique set of processes and stages. These processes encompass monitoring, control, communication, and people management, while the stages involve initiation, requirements gathering, planning, execution, and closure. In this industry, prevalent methodologies include Agile, Kanban, Lean, Six Sigma, and the Waterfall approach.

5. AGILE METHOLOGIES

The founders of agile methodologies are programmers, people who practically deal with software development and find a solution for a successful organization in work. This methodology instructs both software developers and project managers on how to successfully deliver projects within specified timelines and budgets by harnessing the principles of Agile Development (R. I. Cohen, 2018). Several practical case studies are provided, demonstrating the processes of software program planning, testing, refactoring, and implementation. Agile methodologies include Scrum framework, Kanban, Scaled Scrum, Scrum for developers, Agile Leadership evidence based management, Scrum with User experience (D. B. Kimsey, 2010). Working with these methodologies aligns precisely with the principles outlined in the Agile Manifesto, ensuring a clear understanding of the workflow and expectations (Y. Z. Mehrjerdi, 2011). This document emphasizes:

- Prioritizing individuals and interactions over processes and tools.
- Valuing working software over extensive documentation.
- Encouraging customer collaboration rather than focusing solely on contract negotiations.
- Adapting to change instead of following a plan.

Using agile management is a project management approach characterized by continuous collaboration and iterative work. Agile project management operates on the principle that a project can undergo continuous enhancements throughout its life cycle, allowing for swift and responsible changes. Agile stands out as a widely favored project management approach due to its flexibility, ability to adapt to change, and significant customer involvement. In Agile software development, there's a structured progression through six key stages: concept, initiation, iteration, release, maintenance, and retirement, representing the journey of a product from inception to completion (Reosekar, 2014).

Figure 1. Agile life cycle.
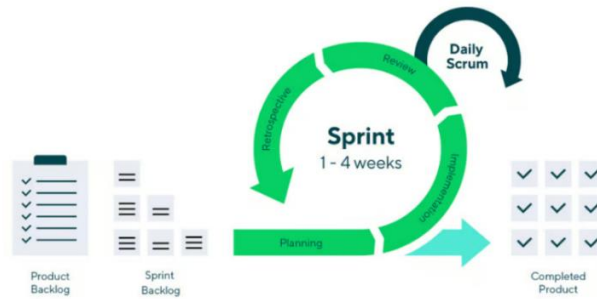
Source: Scrum.org. (2020).

The Agile life cycle varies based on the project management methodology adopted by the team. For instance, in the Scrum framework, teams operate in brief timeframes called sprints, akin to iterations. Additionally, there are well-defined roles within the team, including Scrum Master, Product Owner, and Development team (Heriyanti, 2020). On the other hand, Kanban teams follow a more constant flow without specific mandated roles. Extreme programming, another example, emphasizes shorter iterations and places a strong emphasis on engineering practices. However, the goal of all software development teams remains consistent: delivering completed software to users within the designated timeframe.

Recent research indicates a growing presence of agile methodologies in the machine industry. The principles underlying agile methodologies have proven to be highly valuable and applicable in the machine industry, especially in work planning and organization. After demonstrating their effectiveness in the software industry, these methodologies are now being adopted in various sectors, including the machine industry.

6. METHOLOGIES USED IN THE IT AND MACHINE INDUSTRY

Lean is a business methodology that emphasizes delivering value to customers by adhering to two core principles: continuous improvement and respect for people. Its widespread adoption occurred primarily in the context of process enhancement at Toyota Motor Company (R. C. Martin, 2003). Currently, the healthcare sector extensively employs Lean methodologies to enhance patient care delivery. Lean incorporates various tools and emphasizes continuous improvement with a long-term perspective. Its primary objective is to eliminate patient-perceived waste, ensuring maximum quality and safety. Achieving lasting success demands significant shifts in institutional culture, innovative leadership, and motivated healthcare professionals at the frontline (https://www.scrum.org/, 2020).

Six Sigma possesses the capability to revolutionize an organization's quality initiatives. It is a business methodology designed to enhance processes, minimize waste and errors, and boost overall customer satisfaction across the entire organization. Driven by data and statistical analysis, Six Sigma provides a way to minimize errors and optimize value in all business processes, from production to management (https://agilemanifesto.org/, 2020). Six Sigma is a methodology used to identify and rectify inefficiencies or excessive errors in a process. Its goal is to minimize manufacturing defects to fewer than 3.4 per 1 million units (Leau, 2012). Some key considerations for optimal application of Six Sigma include:

- Minimizing wastage, including time, materials, and resources.
- Decreasing defects and variations in products or services.
- Pinpointing the root causes of process issues.
- Enhancing the utilization of data for improved efficiency and productivity.
- Boosting satisfaction levels among customers and employees.
- Developing new processes or redesigning existing ones that have proven to be ineffective.

The Waterfall methodology, also referred to as the waterfall model, is a linear development process that progresses sequentially through project phases (analysis, design, development, and testing). Each phase is finished before the next one starts, resembling a flowing waterfall. This methodology aligns with the principle of "measure twice, cut once." The effectiveness of the Waterfall method relies on thorough upfront work, including comprehensive documentation of elements such as user interface, user stories, and all feature variations and outcomes (Mundra, 2013). Since a significant portion of project research is conducted beforehand, the Waterfall methodology enables more precise time estimations for each requirement, leading to a more predictable project completion date. However,

if parameters change during development, it's challenging to modify the predefined plan compared to Agile methodology. It has become evident over time that changes are frequent, making it difficult to anticipate everything in advance.
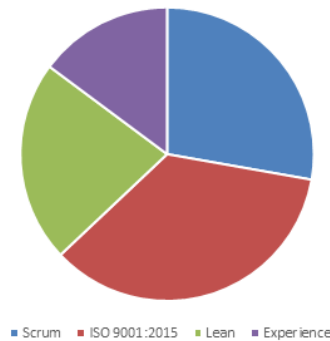
7. USAGE OF WORK METHODOLOGIES IN THE MACHINE INDUSTRY

Following a survey conducted in three prominent companies, Fakom AD, Johnson Matthey, and Van Hool, within the machine industry and having offices in North Macedonia, England, and Belgium, it was found that 87% of the surveyed workforce acknowledged the use of specific methodologies in organizing work processes. The survey encompassed employees (50%), managers (37.5%), and directors (12.5%) across these companies. One of the mentioned methodologies is Lean. However, despite many respondents claiming to adhere to specific standards, in practice, they do not consistently implement particular management principles or work methodologies. On a scale of 1-5, participants indicated that adopting a specific methodology would enhance their productivity in the following manner:

Every single respondent, constituting 100% of the participants, affirmed that the implementation of a methodology in work organization significantly influences the quality of the end product or service. Additionally, 87.5% of the surveyed company employees reported having a supervisor responsible for organizing their work.

The research findings reveal unanimous agreement among employees in the machine industry regarding the importance of adhering to specific methodologies. They believe that such adherence would lead to increased productivity and improved quality of the final product or service. One suggested approach that could significantly enhance daily operations in this industry is the adoption of agile methodologies. These methodologies are already extensively utilized in the IT sector with great success.

Chart 1. Types of work methodologies in the machine industry.

■ Scrum ■ ISO 9001:2015 ■ Lean ■ Experience

8. USAGE OF WORK METHODOLOGIES IN THE IT INDUSTRY

Through a survey conducted in IT companies across North Macedonia, Serbia, Türkiye, and Sweden (Seavus), it was found that 84% of participants incorporate a management methodology in their work. This includes 64% employees, 32% managers, and 4% directors from the surveyed companies. The survey revealed that agile methodologies, the Scrum framework, and PMP agile are widely utilized within this industry based on the received responses. In the study, 64% of respondents indicated that the chosen methodology simplifies their daily tasks, while an overwhelming 95% reported a noticeable increase in productivity. Additionally, 95.7% stated that the selection of a suitable methodology significantly impacts the quality of the final product or service they deliver. Among the surveyed employees, 68% have managers responsible for organizing their work, and 91.6% expressed satisfaction with both the organization of their daily tasks and the established work processes.

Chart 2. Types of work methodologies in the IT industry.

■ Scrum   ■ Agile   ■ PMP   ■ Scaled Scrum
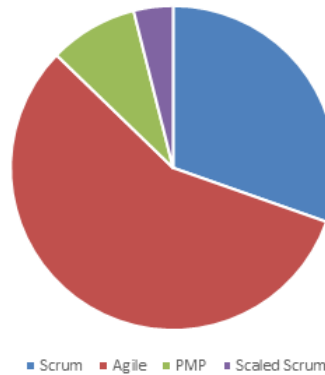
9. WORK METHODOLOGIES USED IN THE IT AND MACHINE INDUSTRY

In both the IT and machine industries, agile methodologies are widely used. Specifically, the Scrum framework is utilized in both sectors, although its prevalence is significantly higher in IT. This framework undergoes continuous enhancements and updates during work, with new versions being applied in practice. While its adoption is increasing in the mechanical industry, it requires more time to establish deep roots and demonstrate productivity in this sector.

10. CONCLUSION

The comprehensive literature review indicated that both the machine and IT industries rely on managerial principles to organize and manage their work processes. These methodologies have demonstrated significant success, leading to their growing adoption. Moreover, certain principles developed in these fields are applicable to both industries. Research also highlights the machine industry's increasing utilization of technological advancements to enhance their operations. Agile methodologies have gained widespread adoption in organizations owing to their flexibility and numerous advantages over other methods. Specifically, the Scrum framework is notably prevalent in both the machine and IT industries and is applicable in both sectors. The selection of a methodology depends on the project's nature. Currently, various management principles have demonstrated positive outcomes in project management within both industries.

The research conducted allows for a comparison of results between the two industries. In both sectors studied, it became evident that employees express a desire to adopt work methodologies, signaling a shift away from traditional management practices. This clear inclination provides a strong indication that implementing agile methodologies, particularly the Scrum framework, is viable in the machine industry too, given its prevalence in the IT sector.

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