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SOFTWARE SOLUTIONS FOR ENHANCING OPERATIONS MANAGEMENT

Exploring low-code as a fix for fragmented systems

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ABSTRACT

Melina Ruusunen: Software solutions for enhancing operations management: Exploring low-code as a fix for fragmented systems
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Low-code development platforms are becoming increasingly common in industrial environments as companies seek to improve their operational efficiency through digital tools. This master's thesis explores digital solutions for supporting operations management in manufacturing environments, with a particular focus on examining the potential role of low-code platforms as part of broader digitalization efforts. Low-code platforms are designed to enable non-programmers to create applications by using graphical interfaces and predefined logic blocks. These tools are increasingly relevant as companies look for scalable and user-friendly alternatives to traditional software development.

The study explores user and organizational expectations, technical constraints, and integration-related challenges associated with digital tools. The main goals of the thesis are to understand how operations management is evolving in the digital era, assess the case company's current digital tools, evaluate the potential role of low-code platforms, and propose a practical, scalable solution that supports both local operational needs and broader strategic objectives. It evaluates the impacts of low-code platform adoption on workflows, communication, and cross-functional collaboration. Additionally, the thesis considers technical features, integration capabilities, and organizational factors that influence successful implementation. Particular attention is given to how such tools can unify fragmented systems and support daily management practices without the need to replace existing legacy systems.

A qualitative case study approach was used, combining a literature review with ten semi-structured interviews conducted with employees across five countries. The case company operates in the manufacturing industry, and interviewees represented various operational roles within the organization. The findings revealed a wide variance in tool usage, with many sites relying on manual workarounds or disconnected systems. Users emphasized the value of intuitive, transparent tools, while also identifying challenges such as duplicated effort, inconsistent practices, and limited data traceability and transparency.

A Power Apps solution developed at the company's UK site served as a key example of how low-code platforms can improve responsiveness and streamline workflows. The findings underscore the importance of involving end users in development, providing sufficient training, and aligning digital tools with actual work practices. However, challenges remain in achieving standardization, long-term scalability and cross-site compatibility.

Overall, this thesis demonstrates that low-code platforms can bridge gaps between people, tools, and data within a complex manufacturing environment. Rather than replacing legacy systems, they offer a flexible layer of connectivity and customization that can adapt to site-specific needs while supporting broader digitalization efforts. While the study is based on a single case company, the findings may offer practical insights for similar organizations exploring low-code solutions.

Keywords: operations management, low-code development, digital tools, manufacturing digitalization, workflow automation, qualitative case study

TIIVISTELMÄ

Melina Ruusunen: Ohjelmistoratkaisut operatiivisen johtamisen tehostamiseen: Low-code-alustat hajanaisten järjestelmien ratkaisuna
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Low-code-kehitysalustat yleistyvät teollisessa ympäristössä, kun yritykset pyrkivät parantamaan operatiivista tehokkuuttaan digitaalisten työkalujen avulla. Tämä diplomityö tarkastelee digitaalisia ratkaisuja, joilla voidaan tukea valmistavan teollisuuden operatiivista johtamista, keskittyen erityisesti low-code-alustojen mahdolliseen asemaan osana laajempaa digitaalista kehitystä. Low-code-alustat on suunniteltu mahdollistamaan sovellusten kehittäminen myös ilman ohjelmointitaitoja hyödyntäen graafisia käyttöliittymiä ja ennalta määritettyjä loogisia komponentteja. Tällaiset työkalut ovat entistä ajankohtaisempia, kun yritykset etsivät skaalautuvia ja käyttäjäystävällisiä vaihtoehtoja perinteiselle ohjelmistokehitykselle.

Tutkimuksessa tarkastellaan käyttäjien ja organisaation odotuksia, teknisiä rajoitteita sekä integraatiohaasteita liittyen digitaalisiin työkaluihin. Diplomityön päätavoitteena on ymmärtää, miten operatiivinen johtaminen kehittyy digitalisaation myötä, arvioida tapausyrityksen nykyisiä digitaalisia ratkaisuja, kartoittaa low-code-alustojen potentiaalia sekä löytää käytännöllinen ja skaalautuva ratkaisu, joka tukee sekä paikallisia operatiivisia tarpeita että yrityksen laajempia strategisia tavoitteita. Työssä arvioidaan low-code alustojen vaikutuksia työnkulkuihin, viestintään ja osastojen väliseen yhteistyöhön. Lisäksi työssä käsitellään teknisiä ominaisuuksia, integraatiomahdollisuuksia sekä organisatorisia tekijöitä, jotka vaikuttavat onnistuneeseen käyttöönottoon. Erityistä huomiota kiinnitetään näiden työkalujen rooliin hajanaisten järjestelmien yhdistämisessä ja päivittäisen johtamisen tukemisessa ilman tarvetta korvata olemassa olevia taustajärjestelmiä.

Työ toteutettiin laadullisena tapaustutkimuksena, jossa yhdistettiin kirjallisuuskatsaus ja kymmenen puolistrukturoitua haastattelua viidessä eri maassa toimineiden työntekijöiden kanssa. Tapausyritys toimii valmistavan teollisuuden alalla, ja haastateltavat edustivat erilaisia operatiivisia rooleja organisaation sisällä. Haastatteluissa nousi esiin merkittäviä eroja työkalujen käytössä: monilla tehtailla hyödynnettiin manuaalisia kiertoteitä ja toisistaan irrallisia järjestelmiä. Käyttäjät korostivat intuitiivisten ja läpinäkyvien työkalujen merkitystä, mutta toivat esiin myös haasteita, kuten päällekkäistä työtä, epäyhtenäisiä käytäntöjä sekä puutteita tiedon jäljitettävyydessä ja läpinäkyvyydessä.

Yrityksen Ison-Britannian tehtaalla kehitetty Power Apps -ratkaisu toimi keskeisenä esimerkkinä siitä, kuinka low-code-alustat voivat parantaa reagointikykyä ja tehostaa työnkulkuja. Tulokset korostavat loppukäyttäjien osallistamista, riittävää koulutusta sekä työkalujen sovittamista arjen käytäntöihin. Haasteita esiintyy kuitenkin edelleen standardoinnissa, skaalautuvuudessa ja yhteensopivuudessa eri toimipaikkojen välillä.

Kokonaisuudessaan työ osoittaa, että low-code-alustat voivat toimia siltana ihmisten, työkalujen ja tiedon välillä monimutkaisissa valmistusympäristöissä. Sen sijaan että ne korvaisivat vanhat järjestelmät, ne tarjoavat joustavan kerroksen, joka mahdollistaa toimintojen yhdistämisen ja paikallisiin tarpeisiin mukautumisen, samalla kun ne tukevat laajempia digitalisaatiopyrkimyksiä. Vaikka tutkimus perustuu yhteen tapausyritykseen, sen havainnot voivat tarjota käytännönläheisiä oivalluksia muille vastaavia ratkaisuja harkitseville organisaatioille.

Avainsanat: operatiivinen johtaminen, low-code-kehitys, digitaaliset työkalut, valmistavan teollisuuden digitalisaatio, työnkulkujen automatisointi, laadullinen tapaustutkimus

USE OF AI IN THESIS

I have utilised AI tools in my thesis:

- ☐ No
- ☒ Yes

The AI tools utilised in my thesis and their purposes are described below:

Names and versions of AI tools: ChatGPT (GPT-4o, GPT-4o mini), Scopus AI

Purpose of using AI tools: AI tools were used to check grammar, sentence structure, and point out typos throughout the thesis. They were also used for brainstorming keywords and search terms during the literature review process, as well as for generating inspiration on how to structure the thesis logically, including ideas for chapter and subchapter division. In some cases, AI was used to help rephrase or better articulate ideas that were already clear in intent but difficult to express fluently or academically.

Sections where AI tools were used: Some usage throughout all the chapters of the thesis

I acknowledge that I am fully responsible for the entire content of my thesis, including the parts generated by AI, and accept accountability for any violations of ethical standards in publications.

PREFACE

This thesis is the final step of my studies at Tampere University, and working on it has been a rewarding experience. I've really enjoyed the chance to dive into the topic, learn new things, and see everything come together.

Thank you to the case company for the opportunity to conduct this study within their organization. Special thanks to all the employees who participated in the interviews, your thoughts were essential to this work. I'd also like to thank my instructors from both the work and university sides for their helpful comments and support along the way.

Lastly, thank you to everyone who supported me during this project, whether through advice, encouragement or simply listening. Special thanks to PÄÄryhmä for all the fun memories and for making my study years fly by in the best way.

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Melina Ruusunen

CONTENTS

1. INTRODUCTION

In recent years, digital transformation has become a central theme across industries, particularly in manufacturing, where the integration of advanced software solutions is becoming increasingly important for maintaining operational efficiency and competitiveness (Tian et al., 2023). Operations management traditionally focuses on optimizing the use of resources and minimizing inefficiencies (Anderson et al., 2021). Recently it has evolved to include a broader range of digital tools and strategies. These include the adoption of Industry 4.0 technologies like artificial intelligence, Internet of Things, and big data analytics, all of which aim to boost productivity, reduce waste, and improve supply chain resilience (Hafidy et al., 2024).

As manufacturing environments grow more complex, companies face growing pressure to deliver better efficiency, flexibility, and responsiveness. Software solutions are now playing a crucial role in this transformation by streamlining production, improving transparency, and enabling real-time data-driven decision-making (Felsberger & Reiner, 2020). With many organizations shifting away from paper-based or fragmented digital systems to integrated digital platforms, the need for user-friendly, scalable, and cost-effective tools that can be adopted across different roles and sites has become increasingly evident (Ajimati et al., 2025).

One significant development in this area is the use of low-code development platforms. These platforms allow users with minimal programming expertise to design, create and deploy applications which has led to reduced reliance on traditional software developers and has enabled faster and more adaptable responses to operational challenges Alsaadi et al., 2021). Microsoft Power Apps is one example of these platforms, and it allows for the creation of customized applications that can help to automate workflows, collect and analyze operational data, and support continuous improvement initiatives (Gurcan & Taentzer, 2021).

This thesis explores the potential of low-code solutions and how they can be used to improve operations management in manufacturing. The focus is on a case company that operates across multiple countries, where different factories currently use a range of different digital tools and systems to manage operations. As part of the study, these existing approaches are reviewed and evaluated, and a more unified solution is proposed. One solution developed at the company's UK factory using Microsoft Power Apps is also examined and reviewed as a potential model for broader implementation.

The main goals of the thesis are to understand the fundamentals of operations management and its digital evolution, to evaluate the benefits and challenges of using low-code platforms in operational settings, to assess the case company's current digital tools and processes, and to propose a suitable digital solution that enhances operations management while aligning with broader organizational goals. By analyzing existing practices and identifying opportunities for improvement, the study aims to offer practical recommendations for integrating or expanding digital tools. These recommendations consider technical feasibility, long-term scalability, organizational readiness as well as alignment with the company's strategic direction.

The research follows a qualitative approach, combining a literature review with semi-structured interviews conducted with employees from different roles and countries within the case company. This method provides in-depth insights into current practices, existing challenges, and user needs from multiple perspectives. Based on this framework, the study seeks to answer the following research questions: What kinds of digital solutions are available for managing and supporting production operations? What kind of application system would best suit the company's needs, and why? Should the proposed solution be purchased or developed in-house? And finally, what does the implementation of that system require from the organization?

Interview results revealed considerable variation in digital maturity and tool usage across sites. While some factories relied heavily on manual processes and disconnected systems, others had implemented more integrated and efficient workflows. The Power Apps solution from the UK site emerged as a particularly promising model, improving traceability, communication, and responsiveness without replacing legacy systems. These findings underscore the importance of aligning digital tools with real-world practices, involving end users in development, and ensuring scalability and cross-site compatibility.

The rest of this thesis is structured as follows: Chapter 2 introduces the fundamentals of operations management and the role of digital technologies. Chapter 3 examines low-code development, offering a comparison of different platforms and highlighting key benefits and challenges. Chapter 4 presents the research methodology, including the literature review and interview process. Chapter 5 presents the practical implementation of digital tools in the case company, including a variety of operational approaches across different factories. Chapter 6 evaluates the current operational models, highlighting their strengths, weaknesses, and potential areas for improvement. Chapter 7 discusses the development and integration of new digital tools, addressing technical and organizational considerations. Chapter 8 concludes with key findings, recommendations for the company and the limitations of the study.

2. FUNDAMENTALS AND TECHNOLOGIES OF OPERATIONS MANAGEMENT

The following subchapters explain operations management and how digitalization has affected it.

2.1 Operations management and its objectives

Operations management is the management of processes where different inputs like labor, materials and information are transformed into goods and services that provide value to customers (Hill, 2011). The management is important for ensuring that resources are used effectively and efficiently to achieve organizational objectives, whether in manufacturing or service industries. Operations management is also a functional area responsible for making strategic, long-term decisions that impact the entire organization. These decisions must align with the mission and overall strategy of the organization, ensuring that the operations strategy supports the long-term competitive goals of the company. (Anderson et al., 2021)

Essentially, operations management involves planning, coordinating, controlling and organizing resources to optimize performance (Gupta & Starr, 2014). It covers a broad range of activities, including production management, inventory management, quality management and management information systems (Kamauff, 2010). Furthermore, it also includes scheduling work, assigning resources like people or equipment, and offering training options for workers. These tasks require the use of structured methodologies, practical guidelines, and algorithms to ensure smooth execution. (Gupta & Starr, 2014)

A key aspect of operations management is its role in reducing inefficiencies. Even minor inefficiencies, when repeated across large-scale operations, can result in significant waste and financial losses (Anderson et al., 2021). These inefficiencies can have wider impacts than just financial losses. For instance, they can lead to the underutilization of workers' time, causing delays or frustrations in their workflow. Organizations can enhance productivity and improve customer satisfaction by refining processes and optimizing resource allocation. While operations management has traditionally been associated with manufacturing, these objectives are equally critical in service-oriented businesses such as healthcare, retail, and logistics. (Anderson et al., 2021)

A modern theory suggest four pillars for operations management: lean manufacturing, lean six sigma, reconfigurable manufacturing systems and business process redesign. Industry 4.0 technologies can be combined with these operations management practices to create supply chains that are both digitally optimized and highly resilient. (Hafidy et al., 2024)

Industry 4.0 is the fourth industrial revolution where manufacturing industry is going through a change by integrating multiple new digital technologies (Felsberger & Reiner, 2020). It is the combination of information technology and manufacturing technology, and includes technologies such as internet of things, big data analytics, artificial intelligence, blockchain and digital twins. These technologies improve visibility, traceability, automation, and decision-making in supply chains, enhancing resilience. (Hafidy et al., 2024)

Supply chain's resilience is its ability to quickly identify and react to disruptions and smoothly overcome them without affecting operations. Drivers of resilience include anticipation, visibility, flexibility, and robustness. Resilience can be enhanced with digital tools. Industry 4.0 enables real-time data monitoring, predictive analytics and automation to help supply chains adapt to disruptions. (Hafidy et al., 2024)

Industry 4.0 technologies help develop more effective and efficient value chains while reducing resource consumption. The integration of these technologies is central to improving sustainability in manufacturing operations. Sustainability is affected on three levels. Economically there is cost reduction, improved productivity and better decision-making through data analytics and automation. Environmental effects include lower resource consumption and waste reduction. Lastly, socially, there is more human-machine collaboration, improved workplace safety and less repetitive tasks. (Felsberger & Reiner, 2020).

For operations management, industry 4.0 technologies create multiple opportunities. Supply chain visibility can be improved by internet of things and blockchain, trade-offs between cost, speed and quality can be reduced, supply chain transactions can be automated by smart contracts using blockchain, and downtime can be reduced with predictive maintenance through artificial intelligence and internet of things. (Olsen & Tomlin, 2020)

Challenges related to implementation include high investment costs, technical qualifications needs, and integration complexity (Hafidy et al., 2024). The organization's size is also a key factor in affording industry 4.0 technologies with small and medium size companies having problems managing costs, leading to digital divide. Workers need new digital skills for these technologies to work effectively and there might be resistance to change or lack of training, slowing down adoption. Especially artificial intelligence and robotics can introduce workforce displacement concerns requiring upskilling of employees and investments in workforce training. (Felsberger & Reiner, 2020; Olsen & Tomlin, 2020) Additionally, increased connectivity creates vulnerabilities to cyber threats and data breaches, meaning that robust cybersecurity strategies are needed. (Felsberger & Reiner, 2020).

These various approaches and models to operations management and digitalization are interpreted and applied differently across industries and organizations. In the case company, operations management is shaped by a strategic initiative called *Smart Operations*, which brings a specific focus to how global manufacturing and supply chains are managed. From the case company's perspective, operations management is not only about organizing resources and processes efficiently, but also about driving continuous improvement and leveraging global capabilities. Under their internal *Smart Operations* strategy, operations are viewed as globally optimized systems focused on enhanced sourcing, planning, and execution. The aim is to improve asset utilization, responsiveness, and service level to customers while reducing lead times, working capital, and operational costs. *Smart Operations* incorporates advanced technologies to optimize machine performance, support in-line quality inspection, and enable assisted machine steering. This approach reflects a shift from regionally managed supply chains to a globally integrated model that relies heavily on digitalization and continuous improvement to drive excellence in productivity, quality, and reliability.

2.2 Digital tools in operations management

Artificial intelligence refers to computer systems that can mimic human intelligence by performing tasks such as recognition, decision-making, learning, and problem solving. There is descriptive, predictive and prescriptive artificial intelligence. Descriptive recognizes objects, images or patterns, predictive uses historical data to forecast future outcomes and prescriptive recommends or automates decisions based on predictions. All of these can be useful in a manufacturing setting with AI predicting machine failures or optimizing supply chain routes. It can also be used to improve human decision-making by providing data-driven recommendations. (Olsen & Tomlin, 2020)

Artificial intelligence can improve supply chain transparency by helping firms anticipate and meet customer needs by analyzing large amounts of data in real time. Machine learning enables predictive capabilities that support for example risk assessment. Artificial intelligence and machine learning can forecast demand and disruptions, contributing to supply chain resilience. Additionally, by optimizing production schedules, mitigating disruptions and balancing workflows can become easier. (Hafidy et al., 2024) Challenges with integration include the need for powerful computing resources as well as accurate and comprehensive data, which might not always be available. (Olsen & Tomlin, 2020)

Big data analytics helps track real-time data across supply chains, enhancing visibility and risk identification. It also supports tracking and traceability systems by ensuring that product movement can be monitored effectively. Big data analytics are used for predictive analytics allowing for early detection of disruptions. (Hafidy et al., 2024)

Additive manufacturing, also known as three-dimensional printing, is a process that creates physical objects by adding material layer by layer based on a digital 3D model. It can be used to produce complex designs that would not be possible with traditional manufacturing, and it can help reduce waste and the time spent on prototyping. Challenges include material and speed limitations as well as high per-unit costs as additive manufacturing is more viable for low-volume, high-complexity production than mass manufacturing. For operations management, it can improve spare part management by allowing on-demand printing for maintenance. (Olsen & Tomlin, 2020)

Internet of things refers to a network of interconnected sensors and devices that collect and exchange data in real-time. These sensors can be embedded in machines, products, and infrastructure to measure environmental conditions or operational performance. The collected data can then be used to improve efficiency and decision-making, enhance supply chain visibility by tracking inventory, and support smart manufacturing, where machines can adjust operations based on the data. Challenges include data security risks with more connected devices, and data management complexity as the volume of data can grow large. Additionally, installing sensors and upgrading networks can become costly. (Olsen & Tomlin, 2020)

Blockchain is a distributed, secure and immutable ledger that records transactions and data in a decentralized manner. Each entry, a block, is cryptographically linked to the previous one, forming a chain. Automated smart contracts execute transactions based on predefined conditions. Blockchain is good for traceability and supply chain transparency and can lower administrative overhead. Challenges include the need for significant processing power needed for the transactions as well as the dependence on accurate data since if incorrect data is entered into a blockchain, it remains there permanently. (Olsen & Tomlin, 2020)

Advanced robotics and more specifically collaborative robots (cobots) help by automating tasks to improve productivity, safety, and efficiency. Cobots work alongside humans in the same environment through AI and advanced sensors to detect movement and respond dynamically. This has a positive impact on both flexibility and safety. Benefits include reduced risk of human error, lowered labor costs, and increased production consistency. There is also the possibility of lights-out manufacturing, where factories operate with minimal human intervention. Additionally, robots can do the more dangerous tasks, further improving workplace safety. Challenges include high upfront costs, workforce displacement, and the complexity of programming and reconfiguring robots for different tasks. (Olsen & Tomlin, 2020)

RFID (radio-frequency identification) is a technology that enables the tracking and monitoring of inventory by using tags and readers to automatically capture data. RFID tags can provide real-time visibility of inventory flow through a supply chain, that provides high-quality and timely information compared to traditional barcoding systems. A benefit of RFID is the ability to automate data collection, reducing the need for periodic audits. Challenges include potential interference from metal or liquids, and privacy concerns with tracking individuals or products. (Olsen & Tomlin, 2020)

Digital twin refers to a sensor-enabled digital model of a physical object that simulates its real-time behavior in a live setting. It allows for the continuous monitoring and optimization of assets and systems by creating a dynamic, data-rich representation. The benefits of digital twins include improved defect reduction, uptime, and system performance. They also enable better manufacturability design for future products. Challenges include the complexity of managing large-scale, real-time data and the need for advanced algorithms to process and optimize the data. (Olsen & Tomlin, 2020)

Enterprise resource planning (ERP) is an integrated application software used by companies to manage various business processes, including finance, purchasing, sales, human resources, and manufacturing operations. It provides a single, common database for all departments to use, thus improving data accuracy and reducing redundancy of information. Some of the large ERP vendors include SAP and Oracle. Benefits of a well-implemented ERP system include reduced lead times, improved coordination between departments, and enhanced supply chain visibility. Challenges include the high cost of implementation, problems in integrating existing data into the system, and the need for employee training to effectively use the system. (Hill, 2011)

Manufacturing execution system (MES) is used in the manufacturing process, and it connects the planning level of production to the shop floor. It receives information about operations that need to be processed from an ERP system and converts the information into work instructions, production orders, and machine commands. The goal is to provide real-time visibility of all manufacturing operations, and as a result, increase efficiency and machine utilization. (Hafidy et al., 2024) The benefits of MES include reduced manufacturing cycle times, improved product quality, and improved on-time delivery performance. Challenges include the difficulty of integrating MES with existing manufacturing and IT systems, the cost of implementation, and the need for continuous data updates to maintain accuracy. (Hill, 2011)

2.3 Digital transformation

Digital transformation has become a central theme in the manufacturing sector, with companies trying to improve their operations with the integration of new technologies in pursuit of operational efficiency and competitiveness. Digital transformation involves the integration of digital technologies and management approaches that lead to changes in business processes, organizational structures, and value creation. Manufacturing companies are now more aware that in order to maintain their competitive edge, they need to utilize the benefits brought on by digital tools. (Tian et al., 2023) A key component of this process is digitization, which refers to the incorporation of digital technologies into existing workflows or the conversion of information from analog to digital formats (Domański et al., 2023). Many organizations begin their digital transformation journey by digitizing paper-based documents and automating manual processes, which helps streamline operations and reduce reliance on outdated systems (Ajimati et al., 2025; Alsaadi et al., 2021).

From a resource-based view, digital transformation in manufacturing relies heavily on the strategic use of digital resources. These resources include traditional production and equipment data as well as digital resources like cloud and software platforms. (Tian et al., 2023) The integration of these resources allows firms to adopt smarter, more efficient ways of managing their operations, which is crucial to improving their operational efficiency. Beyond simple digitization, digital transformation can also involve integrating existing digital systems with manual process automation or redesigning business models to enhance overall effectiveness (Ajimati et al., 2025).

Digital transformation practices are seen as a sequence of changes beginning with the introduction of digital technologies, followed by changes in management practices, that eventually lead to improved operational results. These practices typically include informatization, Internet Plus and intellectual operation that contribute to improved organizational performance through digital integration (Tian et al., 2023). The implementation of digital technologies, such as artificial intelligence and cloud computing, helps to improve key operational areas like supply chain management, production processes, and organizational structures (Tian et al., 2023).

Smart manufacturing is an essential part of digital transformation. It refers to the ability to connect machines, people, and data in real-time, creating a system that can dynamically manage complex production processes. This interconnected environment makes processes automated, enhances decision making, and promotes collaboration between organizational levels. (Felsberger & Reiner, 2020) Automation plays a crucial role in increasing productivity, enhancing agility, fostering product and service innovations, and improving customer interactions. In addition, the increasing adoption of automation tools minimizes manual effort, improves precision, and accelerates production, contributing to higher efficiency and reliability in manufacturing operations (Ajimati et al., 2025). Data analytics in these systems helps identify inefficiencies, predict potential issues and optimize production workflows (Felsberger & Reiner, 2020).

The main goal of digital transformation in manufacturing is to improve operational efficiency. By integrating digital technologies, firms can optimize production processes, reduce downtime, and improve supply chain performance. Increased data availability allows for the development of predictive models that can anticipate errors and disruptions in real time. This helps firms to be more prepared to implement proactive measures to address potential challenges before they affect production. (Felsberger & Reiner, 2020)

In addition, technologies like virtual machines, robotics, and virtual reality are becoming basic elements of smart manufacturing environments. These technologies create smart networks that allow for real-time interaction between people, machines, and processes, leading to more efficient and responsive operations. (Felsberger & Reiner, 2020) The use of robotics in particular, can reduce manual effort considerably, increase precision, and improve production speed, all of which in combination contribute to improved operational efficiency.

Digital transformation also affects organizational restructuring. When manufacturing firms adopt digital tools, their organizational structures often need to adapt to support new workflows and decision-making processes. This restructuring can lead to more agile and flexible organizations capable of quickly addressing market change and operational concerns. Agile methodologies are becoming more common in digital transformation strategies. They support iterative development, cost reduction, and faster technological implementation that help companies to adapt quickly and speed up application development and delivery. (Sanchis et al., 2020)

While digital transformation has significant benefits for operational efficiency, its impact can vary depending on the competition within a given industry. According to Tian et al. (2023), digital transformation practices have a considerable and positive impact on all three aspects of firms' operational efficiency like physical asset efficiency, working capital efficiency, and workforce productivity. However, these positive associations are weakened as industry competition increases. In highly competitive markets, firms may struggle to fully realize the benefits of digital transformation due to external pressures and the quick pace of technological change. This can make the digital transformation process more complex and challenging, as firms must constantly innovate and adapt their digital strategies to stay ahead of the competition. (Tian et al., 2023)

Despite these challenges, digital transformation is still a necessity for manufacturing firms aiming to remain competitive in a rapidly evolving business environment. The adoption of digital technologies allows firms to differentiate themselves by improving their operational capabilities, improving customer satisfaction, and reducing operational costs. However, successful implementation is not guaranteed. Some companies have faced difficulties with poor organizational awareness and support structures as well as high learning curves, limiting the impact of their digital transformation efforts. The growing reliance on digital technologies highlights the dual role of digital transformation as both a disruptive force and a solution to complex business challenges. (Ajimati et al., 2025) The ability to achieve transformative results is still limited with many companies failing to fully leverage information and communication technologies (Sanchis et al., 2020).

These challenges highlight the importance of strategic implementation, and a clear understanding of how digital tools align with business goals (Ajimati et al., 2025). To address these challenges, organizations are turning to new development approaches that accelerate digital transformation. Three primary development approaches, traditional coding, low-code, and no-code have emerged, each differing in team size, skill requirements, cost, and time needed for product development and deployment (Alsaadi et al., 2021). These approaches enable companies to develop and implement digital solutions more efficiently by offering varying levels of complexity and accessibility, which helps support overall transformation efforts.

In particular, low-code and no-code (LCNC) development platforms are gaining traction as key enablers of digital transformation. These platforms simplify software development and empower non-technical users to contribute to digital initiatives (Ajimati et al., 2025). By improving integration, automating routine processes, and enhancing organizational agility, LCNC solutions help align technological capabilities with evolving business needs.

2.4 Digital daily management and KPI tracking in manufacturing

The integration of digital daily management systems (DDMS) in manufacturing is central to achieving modern operational excellence. DDMS support structured monitoring of performance, compliance, and improvement opportunities by digitizing daily routines such as safety checks, production meetings, and KPI reviews. This digital infrastructure improves data accuracy, cross-departmental visibility, and responsiveness. (Smith et al., 2024)

A standard structure in many manufacturing sites is managing daily improvement (MDI), typically implemented in three levels MDI1–MDI3. MDI1 involves daily shop floor reviews with operators, MDI2 is about team-level performance, and MDI3 supports cross-functional coordination at the managerial level. These meetings are used to discuss key performance indicators, quality issues, safety observations, and improvement actions (Stephens et al., 2023). An MDI walk refers to the structured floor walk conducted by team leaders or managers to observe operations, check compliance, and engage directly in frontline problem-solving (Matey et al., 2021). MDI encourages accountability, root-cause analysis, and daily improvements, forming a backbone for operational excellence. (Matey et al., 2021; Stephens et al., 2023)

Key performance indicators (KPIs) are central to DDMS. These quantifiable metrics help monitor the effectiveness of processes and serve as early warnings for deviations. Typical manufacturing KPIs include OEE (overall equipment effectiveness), first-pass yield, downtime, and safety incidents. With digital tools, KPI data can be collected automatically from machines or input manually by operators into mobile or web-based dashboards. This enables real-time performance tracking, reduces manual reporting burden, and supports proactive decision-making. (Smith et al., 2024)

In addition to the core elements, companies also use DDMS to monitor several other operational metrics critical for maintaining high performance. For example, training compliance can be tracked digitally, with systems storing certification records and verifying that employees are authorized to operate specific equipment or have completed required safety and technical modules (Dacal-Nieto et al., 2022). Maintenance tasks and downtime are also closely monitored, with many systems allowing teams to log issues, schedule preventive maintenance, and analyze recurring equipment failures. Quality deviation logs and non-conformance reports are often digitized within DDMS to streamline root cause analysis and support corrective actions (Smith et al., 2024). Employee engagement is increasingly measured through participation in digital tools such as suggestion platforms or continuous improvement boards, which have been shown to enhance bottom-up communication and motivation (Sievert & Scholz, 2017). Many companies also track waste, both in terms of material loss and inefficient processes, as part of their lean and sustainability objectives. Centralizing these metrics enhances transparency and responsiveness across operational areas (Smith et al., 2024).

Another critical practice is the implementation of 5S or 6S methodology (sort, set in order, shine, standardize, sustain, and sometimes safety) as a foundational lean tool (Jiménez et al., 2019; Sukdeo, 2017). These visual workplace tools are used to organize, clean, and maintain order on the shop floor (Sukdeo, 2017). Regular 5S audits can be embedded into DDMS checklists or automated forms, creating digital logs that drive accountability and track long-term compliance trends (Jiménez et al., 2019).

In line with safety practices, personal protective equipment (PPE) checks are often embedded into start-of-shift routines. These checks ensure compliance with legal and organizational safety standards and and play a critical role in workplace risk prevention. According to safety extensions of the 6S framework, ensuring PPE compliance is not only regulatory but also essential for building a zero-accident culture. (Jiménez et al., 2019)

In the context of DDMS, LCNC platforms offer tangible benefits on the ground. Tools like Microsoft Power Apps allow frontline users to create custom checklists, dashboards, and reporting tools tailored to local needs. These tools facilitate integration with systems like Excel and SharePoint, automate notifications, and support standardization while allowing for local flexibility. (Ajimati et al., 2025; Domański et al., 2023)

In summary, DDMS supported by structured MDI routines, real-time KPI tracking, and lean practices such as 5S/6S and PPE audits, are instrumental in advancing operational efficiency. The rise of LCNC platforms further strengthens the flexibility and scalability of such systems in both large and small manufacturing environments.

3. LOW-CODE DEVELOPMENT

The following subchapters go into low-code development. The characteristics and expectations of low-code development platforms are presented along with the comparison of the most common development platforms. Low-code development is also compared to traditional programming and the perceived benefits and challenges are presented.

3.1 What is low-code development?

Low-code development platforms (LCDPs) have emerged as a transformative approach in software engineering, enabling businesses to define and automate workflows with minimal coding effort. These platforms allow the creation of applications through graphical user interfaces, reducing reliance on traditional programming and making development accessible to both professional developers and non-technical users (Domański et al., 2023; Sahay et al., 2023). By integrating visual programming with data manipulation tools such as forms, tables, and reports, LCDPs enable organizations to streamline their operations efficiently (Sahay et al., 2023; Sanchis et al., 2020).

The evolution of LCDPs is driven by the growing need for rapid software development and the shortage of IT professionals. Low-code platforms act as a bridge between traditional software engineering and business process automation, offering a visual integrated development environment (IDE) that allows users, including citizen developers, to build and deploy applications without considerable prior programming knowledge (Ajimati et al., 2025; Alsaadi et al., 2021). This shift aligns with the broader low-code/no-code (LCNC) movement, which has gained traction across industries as a means to make software development available for all (Domański et al., 2023; Gomes & Brito, 2022).

Traditional software development includes the need to make complex architectural choices and requires dedicated teams of professional developers. In contrast, low-code approaches automate most of the coding process with model-driven design and code generation, significantly reducing the time and cost associated with application development and maintenance (Alsaadi et al., 2021; Pinho et al., 2023). No-code platforms take this a step further by eliminating the need for coding altogether, relying entirely on visual modeling and predefined structures to create functional applications. However, these solutions may have limitations in flexibility and functionalities compared to low-code approaches, which allow for additional customization when necessary (Alsaadi et al., 2021; Sanchis et al., 2020).

While LCDPs simplify software development, they are not without challenges. Complex applications often require integration with various technologies, frameworks, and business rules, necessitating ongoing collaboration between developers and stakeholders to ensure alignment with business needs (Pinho et al., 2023; Sahay et al., 2020). Additionally, although low-code platforms lower the barrier to entry, effective utilization still requires domain-specific knowledge to design and implement robust solutions (Pinho et al., 2023).

The adoption of LCNC technologies is expanding rapidly, with projections made already in 2021 indicating that by 2025, they would account for 70% of application development (Gartner, 2021). Platforms such as OutSystems, Microsoft Power Apps, Salesforce, Appian, Mendix, and Zoho Creator have gained popularity by catering to both technical and non-technical users (Ajimati et al., 2025). The broadening scope of LCDPs demonstrates their increasing role in digital transformation, enabling businesses to create tailored applications without being entirely dependent on IT departments (Ajimati et al., 2025; Alsaadi et al., 2021).

LCDPs have revolutionized the way software is developed by providing an intuitive, visual approach to software development. Their integration into enterprise environments supports the rapid development and deployment of software, making technology more accessible while reducing development complexities. As these platforms continue to evolve, they are expected to play a crucial role in shaping the future of software engineering and business automation (Gomes & Brito, 2022; Gurcan & Taentzer, 2021; Sahay et al., 2023).

Characteristics of LCDPs

LCDPs are distinguished by several defining features that set them apart from conventional software development approaches. One of their key characteristics is their ability to facilitate business process automation through different workflow modeling techniques. These methods range from visual drag-and-drop tools often inspired by business process modeling and notation (BPMN) to non-BPMN-based structures that rely on programming languages or hierarchical decision trees. Some platforms combine these approaches, offering a hybrid framework that allows for greater flexibility in process design. Depending on the platform, business logic can be specified through proprietary or widely used programming languages such as Java, JavaScript, and SQL, which are used in platforms like Zoho Creator and Salesforce Lightning. Others, like Microsoft Power Apps and Google AppSheet, structure workflows in a hierarchical format, where predefined conditions trigger sequences of events. Additionally, some platforms generate BPMN workflows automatically, while others allow users to define them manually for greater customization. Hybrid modeling, where multiple workflow specification methods are combined, is commonly adopted in platforms like Microsoft Power Apps and Salesforce Lightning. (Sahay et al., 2023)

Another essential aspect of LCDPs is their ability to seamlessly integrate with external data sources. Many platforms support importing and synchronizing data from sources like Microsoft Excel, Azure, and SQL databases. For example, Microsoft Power Apps and Google AppSheet allow users to import complete datasets, making sure that any modifications made within the platform are automatically reflected in the original data source. This ability to maintain synchronization streamlines business processes and enhances data consistency across different systems. (Sahay et al., 2023)

Usability plays a crucial role in the adoption and effectiveness of LCDPs as users are highly aware of the usability quality of the tools they use. There is an increasing focus on the importance of usability in low-code tools, with users valuing the intuitiveness and ease of use on these platforms. While usability factors are sometimes considered implicitly, they are essential in improving the overall user experience. Key areas that need attention include minimizing errors and refining collaboration capabilities, with many platforms integrating methodologies like Agile, Kanban, and Scrum to support iterative development and teamwork, both of which directly impact user satisfaction. Additionally, the learning curve of LCDPs should be approached from the perspective of enhancing learnability and reducing errors, ensuring a smoother and more efficient user experience. (Pinho et al., 2023; Sahay et al., 2020)

LCDPs are generally built on four fundamental layers that define their architecture and functionality. The application layer provides the graphical interface where users interact with pre-built components to construct applications. The service integration layer enables connectivity with external services through APIs and authentication protocols, ensuring seamless interaction with third-party systems. The data integration layer ensures smooth communication with various databases, managing data exchange. Finally, the deployment layer offers options for cloud-based or on-premise hosting, allowing businesses to choose deployment environments that best suit their needs. Additionally, the automation of backend processes, such as authentication management, load balancing, and data integrity checks, ensures that developers can focus on application logic without dealing with complex technical configurations. (Sahay et al., 2020)

To support the concepts discussed above, Table 1 outlines the key characteristics that define how low-code platforms function, focusing on their structure, integration capabilities, and deployment flexibility.

Table 1. *Key characteristics of low-code platforms*

Characteristic	**Description**
Visual development	Drag-and-drop interfaces and model-based workflows for app building
Reusable components	Pre-built templates, connectors, and logic blocks
Integration capabilities	APIs and connectors to link with existing systems
Automation support	Built-in tools for automating tasks and workflows
Scalability	Varies by platform, some support enterprise-wide deployment
Accessibility	Designed for both technical and non-technical users
Deployment options	Cloud-based, on-premises, or hybrid depending on platform

These characteristics reflect how low-code platforms are designed to balance technical functionality with accessibility, making them suitable for a wide range of users and use cases while supporting scalable and integrated development environments.

Expectations from LCDPs

LCDPs are expected to meet a range of criteria that enhance user engagement, flexibility, scalability, and cost efficiency. As businesses increasingly rely on these platforms for application development, their success is determined by how well they cater to the needs of both technical and non-technical users while maintaining long-term sustainability.

A key expectation from LCDPs is their ability to provide an intuitive and user-friendly interface. The primary goal of low-code solutions is to enable novice developers and business professionals to build applications with minimal technical expertise (Alsaadi et al., 2021). Platforms should feature straightforward navigation, drag-and-drop functionality, and well-organized UI elements to reduce the learning curve and maximize accessibility. Customizable templates and modular components further enhance usability, allowing users to create applications quickly without needing to build from scratch. (Domański et al., 2023)

Flexibility and adaptability are also crucial in LCDPs. Businesses require platforms that can accommodate diverse operational needs through custom workflows, adjustable reports, and tailored user interfaces. A modular design approach ensures that companies can scale and modify applications incrementally without requiring extensive redevelopment (Domański et al., 2023). Furthermore, organizations seek LCDPs that balance customization with cost efficiency, as extensive personalization can sometimes lead to high development costs (Ajimati et al., 2025).

Scalability is a defining feature of effective LCDPs, ensuring that applications can handle increasing workloads, growing user bases, and expanding data volumes without performance degradation. Platforms should support continuous development and extensibility, allowing businesses to iteratively improve their applications as their needs evolve (Domański et al., 2023; Sahay et al., 2020). Additionally, LCDPs should integrate seamlessly with existing IT infrastructures and third-party services to prevent data silos and enhance business process automation (Ajimati et al., 2025).

Reliable service and support are fundamental to ensuring business continuity. Users expect responsive technical support, proactive maintenance, and ongoing development to address emerging challenges and ensure platform longevity. Businesses also benefit from service offerings such as onboarding assistance and regular check-ins, which help maximize the platform's potential and ensure optimal utilization. (Domański et al., 2023)

Cost-effectiveness is another critical factor in selecting an LCDP. Organizations expect pricing models that align with their budgets while providing strong value in terms of features and capabilities. Tiered pricing models, transparent cost structures, and pay-as-you-go options help businesses manage expenses efficiently (Domański et al., 2023; Sanchis et al., 2020).

LCDPs must prioritize usability, flexibility, scalability, service reliability, and cost efficiency to meet the evolving needs of businesses. By streamlining development through intuitive tools, supporting adaptable and scalable architectures, providing robust service support, and maintaining cost transparency, LCDPs can help organizations to drive digital transformation efficiently.

3.2 Comparison of low-code platforms

Each LCDP offers distinct advantages based on business needs, industry requirements, and technical expertise. Among the most prominent platforms are OutSystems (OutSystems, 2025b), Mendix (Mendix, 2025c), Microsoft Power Apps (Microsoft, 2025e), Zoho Creator (Zoho, 2025d), Salesforce Lightning (Salesforce, 2025), Thinkwise (Thinkwise, 2025) and Google AppSheet (Google AppSheet, 2025). Each of these platforms has unique features that cater to different development needs and user requirements.

OutSystems provides a visual, model-driven environment with AI-powered assistance. It focuses on developing enterprise applications that support automation for business processes such as invoicing and order management (Sahay et al., 2023). A key strength of OutSystems is its emphasis on scalability and security, making it a robust choice for organizations looking for long-term solutions (Alsaadi et al., 2021). Additionally, its architecture facilitates easy updates and database modifications without causing errors, ensuring efficient application maintenance. The platform's code generator takes the application model developed in the visual editor and automatically generates native application components, ready to be deployed (Martins et al., 2020). This streamlines the development process and ensures consistency across different environments. It isn’t possible to directly query and retrieve data from an Excel sheet without using an external API (Sahay et al., 2023). The platform includes two primary tools: Service Studio, which handles front-end development by building applications with a visual, model-driven approach, and Integration Studio, which allows developers to build custom extensions and integrate third-party services (Sahay et al., 2020). OutSystems also offers a platform server that supports the deployment of generated application components to an application server and ensures their installation across different frontend servers in the organization’s infrastructure (Martins et al., 2020).

Mendix, another leading LCDP, combines visual modeling with low-code integration. It features Microflows, a modeling tool based on the BPMN standard, enabling users to define application logic efficiently (Sahay et al., 2023). Mendix separates its development environments to cater to different skill levels. Mendix Studio is designed for business developers with a no-code approach, while Mendix Studio Pro provides professional developers with advanced customization options using Java and JavaScript. The platform’s AI-driven assistant enhances development efficiency, and its cloud-based infrastructure supports scalable application deployment. (Alsaadi et al., 2021; Gurcan & Taentzer, 2021) Mendix also provides a central data repository called the Data Hub, which allows integration of existing organizational data, making it easier to connect and share information between applications. The platform offers a marketplace with prebuilt connectors that help in quickly integrating external services, significantly reducing development time. (Gurcan & Taentzer, 2021)

Microsoft Power Apps offers a flexible cloud-based LCDP with strong integration capabilities (Sahay et al., 2020). It supports both model-driven and canvas-based development approaches. Model-driven apps follow a structured design with a focus on interacting components, whereas canvas apps provide more customization freedom with the possibility of building from scratch. Power Apps uses formulas that are similar to the ones in Excel, making them intuitive for users that are familiar with Office 365. (Gurcan & Taentzer, 2021) The platform integrates seamlessly with Office 365, Microsoft SharePoint, and third-party services like Salesforce and SAP (Sahay et al., 2023). There are over 325 pre-implemented connectors to other services with the possibility to build custom connectors to integrate APIs or other services that are not available by default. It includes Power Automate, which facilitates workflow automation and data transfer between connected services. Additionally, Microsoft Power Apps offers an on-premises data gateway that acts as a bridge for transferring data between local and cloud-based systems. (Gurcan & Taentzer, 2021) This feature is particularly valuable for organizations that need to keep certain data on-premises for regulatory or security reasons.

Zoho Creator is a cloud-based LCDP designed for users with minimal coding expertise. It utilizes a scripting language called Deluge to create workflows, enabling conditional operations and data manipulations. Zoho Creator excels in rapid application development, allowing users to integrate external databases and automate routine business processes with minimal effort. (Sahay et al., 2023)

Salesforce Lightning is a well-established LCDP that specializes in customer relationship management (CRM) applications (Alsaadi et al., 2021). It uses automated BPMN along with code-based modeling using the Apex programming language, which is a proprietary language developed by Salesforce (Sahay et al., 2023). It enables organizations to develop applications tailored to customer interactions, with pre-built templates and drag-and-drop functionality for workflow automation. The platform is particularly popular among enterprises that prioritize user engagement and customer data management. (Sahay et al., 2020)

Thinkwise is a low-code platform catering to large-scale business applications. Unlike other LCDPs, Thinkwise supports multiple programming languages, including SQL, R, and Java, providing greater flexibility for complex workflows. It also offers BPMN-based modeling tools for defining business processes and optimizing enterprise workflows. (Sahay et al., 2023)

Google AppSheet is Google's LCDP designed for app development and workflow automation. It integrates with services like Google Drive, Dropbox, and Smartsheet, enabling seamless data access. AppSheet provides pre-built workflows that users can customize to suit their business requirements. It also and supports integrations with automation tools like Zapier and IFTTT, expanding its functionality beyond Google's ecosystem. (Sahay et al., 2023)

Beyond these platforms, several other LCDPs have gained industry recognition. Companies like Appian, K2, Oracle Application Express (APEX), and Pega BPM provide specialized low-code solutions tailored to enterprise needs (Domański et al., 2023). Analysts from Forrester and Gartner have identified Mendix, Microsoft PowerApps, OutSystems, and Salesforce as leaders in the LCDP market, underscoring their strong adoption and extensive feature sets (Pinho et al., 2023).

In addition, major cloud providers like Google and Microsoft have integrated LCDPs into their broader service offerings. Google App Maker and Microsoft Power Platform are examples of how these industry giants are leveraging low-code development to enhance their ecosystems. By incorporating pre-built connectors and integration with their existing services, they enable organizations to build applications quickly while maintaining compatibility with enterprise software solutions.

3.3 Low-code vs. traditional development

The decision to adopt LCDPs over traditional software development methods depends on various factors like business requirements, scalability, cost, and organizational readiness. While LCDPs offer significant advantages in terms of speed, accessibility, and automation, some organizations still prefer traditional development practices due to concerns over scalability, security, and long-term sustainability.

One of the main limitations of traditional development is that it takes a long time and a lot of effort to meet business requirements. Developing custom applications through traditional methods often includes challenges like long development cycles, limited flexibility, and the need for highly skilled developers, making traditional development costly and sometimes inefficient. In contrast, LCDPs significantly reduce development time by providing visual programming interfaces, automation, and pre-built components, which leads to more efficient application deployment. (Alsaadi et al., 2021)

Digital transformation is also driving the adoption of LCDPs. Businesses are more and more looking for ways to enhance agility, respond to evolving market needs, and involve non-technical employees to participate in software development. LCDPs enable digital innovation with faster application updates and reducing dependence on specialized IT staff. (Alsaadi et al., 2021)

Despite these advantages, some organizations are still hesitant to fully adopt LCDPs due to concerns about vendor lock-in, security, and scalability. Many businesses are concerned that relying on a specific low-code vendor may limit their flexibility and make it difficult to transfer applications in the future. Additionally, while LCDPs enable rapid development, there is skepticism about whether they can support highly complex applications with high customization needs. Compliance and security risks are also common reasons for organizations to opt for traditional development approaches. (Ajimati et al., 2025; Alsaadi et al., 2021)

From a development perspective, traditional software development requires a high level of manual coding effort, testing, and deployment, which can be expensive and time-consuming (Ajimati et al., 2025). The developers often need to manually create data schemas, write complex code for the business logic, and built user interfaces from scratch. All of these require significant skill and expertise and can lead to longer development cycles, higher labor costs, and possible errors.

In contrast, LCDPs simplify the development process with a structured workflow that has five main stages: data modeling, user interface definition, business logic specification, external service integration, and deployment**.** Each of these stages in an LCDP typically includes visual, drag-and-drop tools that reduce the need for manual coding. For instance, in data modeling, users are able to visually create data schemas, define entities, and set up relationships using simple interfaces, without having to manually write SQL or other data schema code as in traditional development. Similarly, user interface definition in LCDPs includes configuring forms and pages visually, leading to faster UI design compared to for example hand-coding HTML, CSS, and JavaScript. (Sahay et al., 2020)

In the business logic specification stage, LCDPs use graphical workflows, often employing BPMN-like notations to define the logic. This contrasts again with traditional development, where developers have to manually code the logic. External service integration is also simplified in LCDP with built-in capabilities to integrate third-party APIs as compared to traditional development where the custom integration code needs to be written. Finally, the deployment stage in LCDPs is streamlined with features that allow for quick previews and one-click deployment, reducing time and complexity compared to manual configuration and deployment. (Sahay et al., 2020)

Organizations must analyze LCDPs by considering their suitability based on business size and application type. LCDPs are commonly used for both Business-to-Business (B2B) and Business-to-Customer (B2C) solutions, helping organizations to automate business processes and optimize workflows. Choosing the right LCDP tailored to a company's operational needs is crucial for scaling operations while maintaining cost control (Sahay et al., 2020). By understanding the advantages and limitations of both approaches, businesses can make informed decisions on the best development strategy for their needs.

3.4 Benefits and challenges of low-code

The perceived benefits and challenges of low-code development are presented below.

Benefits

LCDPs provide significant advantages, making application development more accessible to non-programmers while improving efficiency, fostering digital innovation, and reducing costs. One of the most widely acknowledged benefits is the ability to create applications rapidly. LCDPs allow users to design applications using visual tools, significantly reducing development time (Alsaadi et al., 2021; Sanchis et al., 2020). Additionally, LCDPs enable non-programmers to develop software, thereby democratizing application development and lowering the barrier to entry for business users (Alsaadi et al., 2021; Pinho et al., 2023).

The cost-effectiveness of LCDPs is another key advantage. By reducing the development cycle and automating repetitive coding tasks, businesses can cut expenses associated with hiring professional developers and maintaining traditional development teams. Additionally, because LCDPs allow users to quickly develop and iterate on applications, they minimize wasted resources on ideas that may not be viable, ensuring a better allocation of financial and human capital. (Sanchis et al., 2020)

LCDPs also play a crucial role in improving business operations by integrating automation into workflows. These platforms facilitate business process automation by enabling seamless interaction with different integrated data sources, thus increasing operational efficiency and effectiveness. This automation reduces reliance on manual processes, leading to faster execution and fewer errors. (Ajimati et al., 2025)

Another critical benefit is scalability and flexibility. LCDPs enable businesses to scale applications to meet growing demands while maintaining a simplified development approach. Furthermore, LCDPs are designed to easily integrate with external services, ensuring seamless connectivity between newly developed applications and existing enterprise systems. (Ajimati et al., 2025)

From an organizational perspective, LCDPs promote digital transformation by fostering skill development among employees. Business professionals who might not have been exposed to programming can gain digital literacy through the use of these platforms, enabling them to contribute more effectively to technological advancements within their companies. Additionally, LCDPs enhance collaboration between business and IT teams by bridging the knowledge gap, ensuring better alignment between business needs and technical capabilities. (Ajimati et al., 2025)

Security and governance are also notable benefits of LCDPs. Since these platforms allow organizations to maintain control over internal development, they minimize the risks associated with outsourcing software projects. Additionally, the structured development approach ensures maintainability, reducing the complexity involved in software updates and long-term management. (Sanchis et al., 2020)

Lastly, LCDPs support innovation by allowing rapid prototyping and iteration. Developers and business users can quickly test new ideas, gather feedback, and refine applications to align with business goals (Sanchis et al., 2020). This iterative approach enables businesses to stay competitive by continuously improving their digital solutions.

In conclusion, LCDPs offer numerous benefits ranging from rapid development, cost reduction, and business process automation to enhanced scalability, security, and digital skill development. By enabling both professional developers and non-technical users to create, customize, and maintain applications efficiently, these platforms are playing a transformative role in modern enterprise software development

Challenges

While LCDPs offer numerous advantages in terms of efficiency and accessibility, they also present several challenges that organizations and developers must consider before adoption. These challenges span technical, financial, and operational aspects, impacting scalability, flexibility, security, and long-term sustainability.

One of the major concerns associated with LCDPs is their complexity for non-programmers. While these platforms are designed to simplify development, some users find the learning curve too steep, making them ineffective for those without prior technical knowledge (Domański et al., 2023). Additionally, customization of built-in functions can be restrictive, requiring workarounds or additional coding, which contradicts the fundamental principle of low-code development (Alsaadi et al., 2021).

Scalability is another significant issue, particularly for businesses anticipating rapid growth. Many LCDPs are designed for small and medium-scale applications, but their ability to support enterprise-level applications remains limited (Sanchis et al., 2020). Organizations may struggle to scale their applications efficiently, leading to potential performance bottlenecks (Alsaadi et al., 2021).

Another challenge is vendor lock-in, which arises when companies become too dependent on a specific LCDP. Since most platforms are proprietary, switching to another provider can be costly and time-consuming (Ajimati et al., 2025; Gurcan & Taentzer, 2021). This risk is compounded by interoperability concerns, as some platforms have limited integration capabilities with external systems and existing enterprise software (Domański et al., 2023).

Security and compliance pose additional risks. Many LCDPs may not meet industry-specific security standards, which is particularly concerning for sectors like finance and healthcare (Domański et al., 2023). Furthermore, the rise of citizen development, where employees outside IT teams create applications, can lead to security vulnerabilities, data breaches, and governance issues if proper oversight is not maintained (Ajimati et al., 2025).

While low-code platforms democratize development, they can introduce governance challenges, especially when citizen developers work without centralized oversight. Without structured processes or approval workflows, organizations risk creating fragmented and insecure solutions that are commonly referred to as shadow IT (Hoogsteen & Borgman, 2022). To prevent this, research suggests implementing clear guardrails, such as standardized templates, role-based permissions, and IT alignment protocols (Kokala, 2022). These efforts ensure that low-code development remains scalable and secure as organizations grow.

The cost of LCDPs is another crucial factor, as organizations must consider not just the initial licensing fees, but also ongoing expenses related to training, maintenance, and scaling applications (Domański et al., 2023). While LCDPs promise faster development and reduced upfront costs, long-term expenses can accumulate, making them less viable for some businesses.

Another commonly cited drawback is the quality of code generated by LCDPs. Many platforms produce code that lacks proper documentation, making it difficult to debug and maintain (Alsaadi et al., 2021). Additionally, debugging and error tracing in low-code environments can be challenging, particularly when custom extensions or complex business logic are involved (Pinho et al., 2023). Another quality-related issue may arise when the focus on speed in application development comes at the expense of meeting quality requirements, potentially compromising the performance of the final product (Ajimati et al., 2025).

Fragmentation in the low-code ecosystem further complicates adoption. The wide variety of available platforms makes it difficult for businesses to choose the most suitable one, and inconsistencies in development standards hinder interoperability (Sanchis et al., 2020). As a result, companies may struggle to integrate multiple LCDPs into a unified workflow (Ajimati et al., 2025).

Despite these challenges, LCDPs continue to evolve, and organizations are exploring strategies to mitigate risks. Ensuring thorough vendor evaluation, implementing security practices, and developing internal guidelines for citizen development can help organizations leverage low-code development effectively while minimizing its limitations. To provide a clearer overview, Table 2 summarizes the key benefits and challenges associated with low-code development platforms.

Table 2. *Benefits and challenges of low-code development*

Aspect	**Benefits**	**Challenges**
Development speed	Rapid development and deployment with visual tools	Can still be complex for non-technical users, debugging is harder
Cost	Reduces development, maintenance and staffing costs	Long-term costs like licenses or training may offset savings, risk of vendor lock-in
Scalability	Supports growing app demands with simplified tools	Often limited for enterprise-grade needs, performance may suffer
Integration	Connects easily with other systems and services	Limitations with some legacy systems
Security & governance	Central control reduces outsourcing risks and improves maintainability	Risk of shadow IT and compliance issues without strong oversight
Innovation & flexibility	Fast prototyping and iterative improvement, empowers non-programmers, supports digital transformation	May result in low-quality or inconsistent apps without proper controls

As shown in Table 2, low-code platforms offer significant advantages in terms of speed, accessibility, and cost-effectiveness, making them highly attractive for organizations aiming to accelerate digital transformation. However, these benefits are counterbalanced by important risks, including limited scalability, security concerns, and integration constraints. The successful use of low-code tools depends not only on their technical features, but also on careful implementation, governance, and alignment with broader organizational goals. When used effectively, low-code platforms can support innovation and improve operational efficiency.

4. RESEARCH METHODOLOGY

This chapter outlines the study's methodology. It introduces the research approach, the case company context, and the steps taken during data collection and analysis. The aim is to provide transparency on how the research was structured and conducted.

4.1 Research approach and case context

This study follows a qualitative research approach, which is an approach that seeks to understand how individuals perceive and interpret their experiences within specific contexts (Flick, 2018; Gill et al., 2008). Qualitative research emphasizes meaning, context, and depth over measurement, and is particularly suited to exploring complex organizational settings and human perspectives (Flick, 2018). The study combines a literature review with semi-structured interviews. The literature review, presented in Chapters 2 and 3, provides theoretical insights on the topic, while semi-structured interviews are used to gather firsthand information from employees who use the current system.

The research is exploratory, meaning it tries to uncover new insights and patterns rather than test predetermined hypothesis (Kallio et al., 2016). It aims to identify and evaluate different software solutions available for streamlining operations management. The study does not aim to produce statistically generalizable results, but rather to build an in-depth understanding of current practices and perceptions within the case company. This goal is consistent with the nature of qualitative research, which focuses on uncovering meaning and insight rather than statistical inference (DiCicco-Bloom & Crabtree, 2006; Kallio et al., 2016). This makes a qualitative approach suitable for this study as it helps to understand people's experiences more deeply and spot common patterns in what they say (Gill et al., 2008).

Additionally, the study takes a case study approach, focusing on a company that currently manages various operations tasks on multiple digital platforms. The case company operates in the manufacturing industry and has production sites across multiple countries. The study was conducted as an external investigation, with an aim to maintain objectivity in examining the company's current practices and identifying potential areas for improvement, such as system integration and workflow efficiency. The study examines whether it would be beneficial to integrate and centralize the company's key operations-related functions, like production and KPI tracking, into a single system, and what would be the most suitable implementation approach for it.

A case study design is appropriate here because the research focuses on a bounded context and investigates the topic within its real-life setting (Kallio et al., 2016). Case studies are particularly useful in technology implementation research, where the context and system are closely intertwined, and ”how” and ”why” questions are central (Yin, 2018). This approach enables a more comprehensive view of the phenomenon, taking into account the complexity of organizational processes, user behaviors, and system limitations.

The literature review focused on understanding the fundamentals of operations management and how digital transformation and tools can be part of it. Different low-code and no-code platforms were evaluated and compared to a customized software. The review was conducted using Andor, IEEE Xplore and ScienceDirect, with searches that combined the keyword “operations management” with different terms such as “digitalization”, “tool”, “practices”, “production”, “manufacturing” and “platform”. Another approach was combining “low-code” with “development”, “usability”, “no-code”, and “platform”. In addition, truncation was used to expand the results to include inflected forms of the search terms. The queries were kept short and included only two terms at a time since it was noted that the results seemed to deviate when combining more terms.

Some references were found with citation pearl growing by looking at the references used by relevant studies. The review aimed to prioritize peer-reviewed papers to ensure a high level of credibility and reliability, as they have undergone evaluation by experts in the field. While the majority of the sources included were peer-reviewed, a few non-peer-reviewed sources were also used when they provided valuable context or insights not found elsewhere. Filtering by publication year was not necessary, as the results included fairly recent publications. This could be explained by the growing interest in digitalization and the new technologies that have emerged in recent years.

4.2 Case study process and data collection

The case study process was carried out in four main phases. First, a background study was conducted to understand the case context and gather relevant information. This was followed by interviews with selected employees, chosen to represent a variety of roles and departments, ensuring that the needs and experiences of different organizational levels were captured. Using the interview data, the current practices and digital systems in use were described and analyzed. Finally, recommendations were formed based on the findings. These steps formed a clear structure for the study and are illustrated in Figure 1, which summarizes the overall study process.

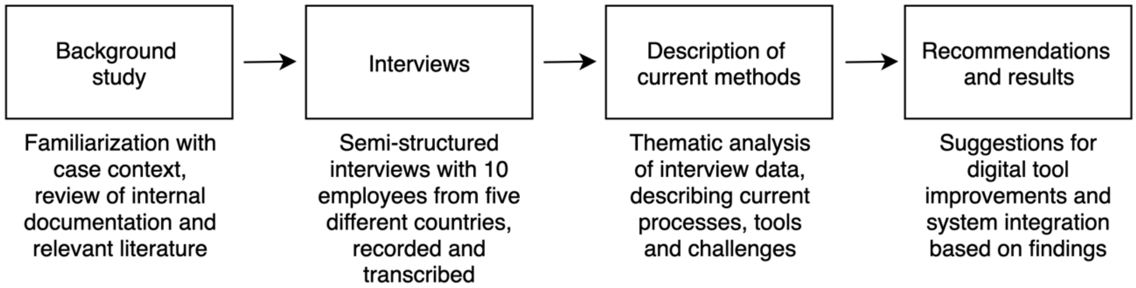

Figure 1. *Case study research process*

Semi-structured interviews were conducted with employees from different roles within the case company who regularly use the digital systems under study. The participants included employees ranging from shop floor roles up to plant-level management, with responsibilities across production and process improvement. Ten interviewees took part, representing five manufacturing plants located in the UK, Italy, the Netherlands, China and Finland. This geographical diversity ensured that the result of the study, the proposed software solution, would fit and match the needs of multiple working cultures. The interviews lasted between 35 and 65 minutes, with an average duration of approximately 45 minutes, providing sufficient depth for comprehensive insights.

A semi-structured interview is an interview where a loose guideline and set of questions are followed but it is open to allowing new ideas to be brought up based on what the interviewee says (Kallio et al., 2016). A set of key questions was asked from all the participants as well as questions that arose from the answers. The list of interview questions used in the study is provided in Appendix A. Semi-structured interviews were chosen to give the participants the opportunity to focus on aspects that were most important to their roles and daily experience.

This interview format is considered highly effective in qualitative research because it enables the interviewer to explore a defined topic while remaining flexible enough to follow up on unexpected insights (Kallio et al., 2016). It also allows space for participants to express themselves in their own terms, which is especially important when discussing personal experiences and context-specific practices (Gill et al., 2008). This flexibility makes semi-structured interviews a widely used method in many fields, especially useful for gaining detailed and nuanced perspectives in complex organizational environments (Roulston & Choi, 2018). According to Kallio et al., a well-designed semi-structured interview enhances the credibility, confirmability, and dependability of a qualitative study through five key phases: defining the prerequisites for using the method, building on prior knowledge, constructing a flexible yet focused guide, pilot testing, and transparently presenting the final version (Kallio et al., 2016). Roulston and Choi (2018) further emphasize that this format supports free-flowing, participant-led dialogue while maintaining alignment with the study's core research topics, making it highly effective for exploring experience and meaning in real-world settings.

The purpose of the interviews was to gain insights into the current practices including potential challenges as well as the aspects that are currently working well. Additionally, thoughts and requirements for a new digital tool were also gathered to see what features were seen as essential. Semi-structured interviews are especially suitable for such exploratory purposes, as they allow in-depth understanding of people's needs, perceptions, and reasoning, making it an approach that aligns with the goals of this research (DiCicco-Bloom & Crabtree, 2006).

The interviews were conducted either onsite at the factory or remotely through Microsoft Teams. All interviews were recorded with the participants' permission and later transcribed for analysis. The recordings helped to make sure that no details were missed and made it possible to revisit the material during the analysis process.

Given the interpretive nature of the study, the research design was informed by the principles of qualitative field research outlined by Klein and Myers (1999). Their framework emphasizes the importance of understanding context, facilitating dialogue, and acknowledging multiple viewpoints during data collection. These principles guided the design of the semi-structured interviews and supported the analysis by emphasizing careful attention to cultural and organizational differences across the company's sites.

The interview data was analyzed using a thematic analysis approach. This method is commonly used in qualitative research to identify and organize patterns or themes within textual data (Braun & Clarke, 2006). Thematic analysis is particularly well-suited for exploratory studies, as it allows for the researcher to stay close to the data while systematically uncovering recurring patterns and insights (Lochmiller, 2021). The analysis started with reading through the transcripts a couple of times to spot common themes and get an overall picture of the findings. Relevant sections were highlighted and coded based on recurring topics such as tools that were used in daily work, workflow efficiency, system challenges, communication practices, and expectations for future digital tools. These initial codes were then reviewed and grouped into broader themes, such as fragmentation in current systems, differences in digital maturity across sites and variability in daily management practices.

This process followed the six-phase model described by Braun and Clarke: familiarization with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report. This structured yet flexible approach helps ensure both rigor and depth in qualitative analysis while keeping the researcher closely connected to the participants' perspectives. (Braun & Clarke, 2006; Nowell et al., 2017)

Themes were not predetermined but appeared inductively from the data, in line with the flexible nature of semi-structured interviews. This approach assured that the findings reflected the real experiences and priorities of the interviewees. Attention was also paid to differences between factories, roles, and geographical contexts in order to surface contrasting views and capture potential barriers to system standardization. The resulting themes were used to guide the structure and content of Chapters 5, 6, and 7, where findings from the interviews are analyzed and discussed in detail.

The combination of a literature-based foundation and real-world user perspectives provided a strong framework for evaluating digital tool implementation in a manufacturing context. It allowed the study to not only assess technological options but also understand their practical implications, usability, and organizational fit.

5. OPERATIONS MANAGEMENT AND DIGITAL TOOLS IN PRACTICE

This chapter presents an overview of how operations management is currently handled across different factories within the case company. The analysis is based on a series of semi-structured interviews conducted with employees in various roles and locations, providing first-hand insights into the day-to-day practices, tools, and systems used to manage production, safety, and improvement efforts. The chapter is divided into two parts: the first focuses on the operational practices in most factories, where a range of digital tools and processes are used with varying levels of structure and consistency; the second part highlights the approach taken at the UK factory, which stands out for its more unified and systematic way of working. Together, these perspectives offer a detailed picture of the current landscape, forming the foundation for the evaluation and recommendations discussed in the following chapter.

5.1 Operations management approaches in the case factories

Across the majority of the case company's manufacturing sites, operations management practices are built upon similar structural intentions but differ significantly in terms of execution, tools used, level of standardization, and the extent of digital integration. While many of the factories follow a shared conceptual model for daily operational control and continuous improvement, the actual practices in place at each site are often locally adapted, manually executed, and heavily reliant on fragmented systems.

General operations management and MDI meetings

A widely used model of daily management in these factories is the MDI (managing daily improvement) structure, which is organized into three levels: MDI1, MDI2, and MDI3. MDI1 describes the daily shop-floor meetings by the machines, during which the supervisors or leaders discuss the activities during the last 24 hours of production. These meetings center around any deviations from production goals, such as safety problems, quality flaws, and staff concerns. MDI2 meetings are attended by managers and representatives from across departments and are conducted in meeting rooms or office spaces. These meetings serve to aggregate information from MDI1 meetings and raise any cross-functional issues needing to be addressed. Last, MDI3 is a weekly meeting attended by a more expansive leadership group, such as plant managers and operational leaders, who discuss the site performance from the preceding week and set key areas of focus for days ahead.

Although the MDI structure is conceptually present at most sites, its practical application varies greatly. For example, in the Finnish factory, this model is relatively well institutionalized, but even there, the implementation of MDI1 meetings is uneven across different departments. In some departments, these meetings are conducted highly consistently and attentively, while in others they have become superficial in nature. Based on interviews, this variability was explained by differences in managerial styles, a lack of time, or the lack of clear follow-up procedures. In other countries, such as China and Italy, the MDI meetings are held but often lack systematic documentation or digital tools to support them. In some cases, MDI1 sessions consist more of informal conversations between the operators and managers rather than structured, data-driven discussions. This makes it challenging to track decisions or to ensure continuity of communication between different shifts and departments.

The tools used to support operations management also vary significantly between sites. Whereas SAP is used by every factory as the enterprise resource planning system, it is sometimes cited as being hard to work with and not conducive to manufacturing teams' individualized workflows. Interviewees reported that tasks such as recording customer complaints, tracking maintenance requests, or retrieving production data tend to involve multiple screens and difficult interfaces, requiring a significant amount of time that may lead to errors. As a result, these users have developed workarounds, like copying data from SAP into Excel spreadsheets or developing simplified forms to obtain data they need. Power BI and Business Objects are also commonly used to visually present key performance indicators, like production volumes, waste percentages, or other metrics. However, these visualizations often rely on manual data extraction, and users need to copy data from multiple sources before it can be presented in meetings or used for decision-making. Not only does this increase the risk of errors but also takes up valuable time that could be spent on more strategic tasks.

Microsoft Teams Planner and SharePoint are used in the Finnish sites to organize and track meeting agendas, action items, and project tasks. These tools are integrated into the MDI2 and MDI3 meetings, allowing teams to follow up on open issues and delegate responsibilities. Although this approach provides a level of structure and traceability, it also highlights a broader challenge: each site or even department tends to build its own collection of tools and processes, without a common, centralized system in place. It means that there is substantial variation in how data are managed, how decisions are recorded, and how responsibilities are followed up across sites. In Teams Planner, as much as tasks are being digitally tracked, the same board is often reused and overwritten, which limits the ability to go back and review past actions or decisions. As a result, long-term traceability is compromised, and there is no clear historical record of completed items or unresolved issues that may have resurfaced later. While the tool has potential for better organization and visibility, this current use undermines long-term accountability and reduces the overall effectiveness of digital tracking.

Safety

Safety management follows a similar pattern. Safety incidents, near misses, and observations are reported using tools such as Kiwa Impact and Hupsis, with the latter being a SharePoint-based solution used primarily in the Finnish factories. Kiwa Impact is widely used for conducting 5S audits, performing risk assessments, and documenting safety walks. However, its usability is often criticized. Several users noted that it is difficult to navigate, particularly when reviewing completed assessments or attempting to identify trends across different departments. Some also pointed out that visualizations within the system are unclear, and the reporting tools do not support effective communication or follow-up.

In contrast, the Hupsis system is generally regarded as easier to use and more intuitive. It was developed in-house using SharePoint and is designed specifically for reporting near misses and safety-related observations. One of its key strengths is its low barrier to use as no separate login is required, and the interface is simple and quick to navigate. This ease of access has helped encourage more frequent reporting from employees. The submitted reports are automatically categorized by status, like open or resolved, which allows all the users to track the progress of reported issues. If a report is marked as resolved without sufficient action or feedback, the original reporter can reopen the discussion, fostering accountability and transparency. Despite its positive reception, Hupsis is not integrated with other operational systems, which means that any follow-up actions still need to be tracked separately. While this limits its functionality in broader workflows, the tool is seen as an effective, lightweight solution that supports local safety practices and encourages user engagement more successfully than heavier systems like Kiwa Impact.

In comparison, safety reporting practices in other factories across the case company vary significantly and often face challenges related to fragmentation, manual processes, or limited follow-up. In the Netherlands, a group-level intranet tool referred to as A3 is used to report near-misses, accidents, and associated corrective actions. This system follows a standardized structure set by the wider organization, and reported cases are forwarded to the group operations manager. While the system creates a formal process for documentation, it is somewhat detached from daily production tools and is perceived as more administrative than operational. In addition, the site uses InstaAudit for conducting 5S and safety-related audits. The tool allows for photo documentation and task assignment, but it is described as only moderately user-friendly, with a basic interface that does not significantly improve engagement or tracking.

At the Italian factory, safety checks are still largely managed using Excel sheets or other local tools, often disconnected from production systems or broader reporting frameworks. As a result, important issues may be discussed during meetings but are not always logged systematically. This reliance on informal communication and personal memory weakens the traceability and consistency of safety follow-up. There is a recognized need for more structured tools, but uptake has been limited, partly due to digital maturity and partly due to the perception that existing methods are "good enough" for day-to-day use.

In the Chinese site, safety and maintenance discussions are included in regular internal meetings between different departments, such as sourcing and maintenance. However, safety reporting itself remains manual, and the coordination between teams can be inconsistent. Interviewees highlighted that there is no clear system for verifying whether a machine is safe to operate after maintenance, and information does not always reach the operators in time. The concept of real-time, system-based communication, like a digital confirmation before restarting a machine, was mentioned as a goal but is not yet in place.

Across many of the sites, a common limitation is that the tools currently used for safety reporting are not well-integrated into other systems or routines. Whether relying on Kiwa Impact, Excel, or intranet forms, the general pattern is that safety information is siloed from production and maintenance data. This makes it difficult to track recurring issues across departments or to link safety performance with broader operational metrics. In contrast to the more fluid and accessible model offered by Hupsis in Finland, other factories often face barriers that reduce both reporting frequency and follow-up quality. This highlights a broader organizational need for more unified and user-friendly systems that not only make reporting easier but also ensure that safety data feeds into continuous improvement efforts in a visible and actionable way. These same issues are reflected in maintenance management, where similar communication gaps and tool fragmentation affect day-to-day coordination.

Maintenance

Maintenance activities are similarly fragmented across the company's international sites. While the overall importance of regular preventive maintenance is universally recognized, the tools, communication methods, and level of integration vary widely from one location to another. At many factories, maintenance continues to rely on manual or semi-digital systems. Teams commonly use Excel spreadsheets, printed schedules, or whiteboards to track maintenance activities, and these records are often accessible only to the maintenance department. This creates communication gaps where production operators or quality managers do not have real-time visibility into the status of critical maintenance tasks. In some cases, production has resumed before maintenance has been properly completed or verified, leading to avoidable disruptions or safety concerns.

For example, at the Chinese factory, the maintenance team works with well-structured schedules, including daily, biweekly, and monthly plans, but these remain entirely manual. There is no integrated communication channel between maintenance and operations teams, which means that even when maintenance is completed, operators are not automatically notified. Interviewees highlighted this as a major issue, suggesting that an ideal system would display a visual confirmation on the machine or a dashboard to indicate whether maintenance had been successfully performed, and the equipment is cleared for use.

The Italian site faces similar challenges. Maintenance has traditionally been performed by highly experienced staff, but the approach has been more reactive than preventive, described as ”fix it when it breaks”. While recent efforts are being made to shift toward more predictive and structured maintenance, including coding spare parts and formalizing schedules, much of the recordkeeping is still done on paper or basic Excel registers. A pilot for a “Smart Maintenance” initiative was underway in one department, aiming to log and plan tasks more systematically with due dates for intended completion.

Finnish factories also rely heavily on Excel spreadsheets, SAP, and SharePoint-based methods to track maintenance activities. While formal schedules are in place, these are often updated manually, such as by marking tasks on boards near the machines and then entering the data into SAP afterward. In many cases, this process is handled by team leads rather than operators themselves, and the maintenance status is not clearly visible to the production team in real time. This fragmented approach has led to situations where machines are restarted before scheduled maintenance has been verified or completed. There have been ideas about implementing more visual indicators on the factory floor or integrating maintenance checks into a centralized system, but such improvements remain largely at the planning stage.

On all sites, a lack of an integrated system of tracking maintenance has led to siloed information, inefficiencies in scheduling, and difficulties in follow-up. There was a common wish from interviewees that a more connected system would enable linking of maintenance planning to a vision of production, giving operators, planners, and quality teams to access up-to-date equipment status without relying on separate communication channels. Some envisioned dashboards where machine readiness could be confirmed in real time, or apps that could synchronize maintenance status with production planning tools.

Fragmentation of tools and practices

A recurring theme throughout the interviews is the localized development of tools and processes in response to specific challenges. In the absence of a standardized, group-wide system for managing daily operations, individual sites and departments have taken the initiative to create their own solutions. For example, in some cases, SharePoint sites have been modified to serve as task trackers, while in others, lightweight applications have been built to simplify complaint logging or maintenance reporting. These solutions are often highly effective in their local context, but they also contribute to the broader issue of fragmentation. Without integration or consistency, information siloes, reporting becomes inconsistent, and collaboration across factories is hindered. Additionally, since these tools are created by single individuals or departments without IT staff to back them, these solutions are not easily sustained in the long term, are difficult to scale, or both.

Interviewees from all sites expressed a shared desire for better integration, increased transparency, and easier access to information. Many pointed out the inefficiencies resulting from having to pull data from multiple systems, double-check numbers, or manually merge reports. “If there isn’t a single system, then at least the integrations should be considered in a way that we don’t end up with eight different systems that don’t talk to each other,” summarized one interviewee, capturing a widespread frustration over system fragmentation and the clear desire for integrated solutions. There was a strong consensus that the current systems in place that may be functional in a basic sense, are not designed for the modern needs of manufacturing operations, particularly when it comes to data-driven decision-making, cross-functional collaboration, and continuous improvement. The constraints of the current setup are not only felt in terms of productivity and efficiency but also in being able to rapidly respond to changes or align globally on common priorities and practices.

Overall, operations management across the non-UK factories is marked by a high level of variability and a reliance on fragmented, locally developed systems. There are numerous indicators of hard work and problem-solving at a local level, but overall, evidence points to an organization lacking cohesion and technological consistency across its various sites. This fragmentation makes it difficult to standardize best practices, scale innovations, and achieve consistency in performance across sites. The next section explains how the UK factory has taken a more unified and systematic approach, presenting a that has potential to be applied across the organization more widely.

5.2 Microsoft Power Apps in operations management

This subchapter explains how the company's UK plant manages operations with a Microsoft Power Apps based network of different apps in use by operators, shift managers as well as the administrative personnel.

5.2.1 How Power Apps support operations

The implementation of Microsoft Power Apps in one the case company's factories has significantly enhanced daily operations management by integrating various functions into digital applications. This digital transformation has streamlined operations, improved efficiency, and replaced manual methods like Microsoft Forms and paper-based tracking, which previously caused inefficiencies and delays. With a number of integrated apps, the company has achieved more consistent, data-driven, and transparent processes, leading to better data tracking, workflow efficiency, and decision-making.

Daily operations management tasks

The apps play a crucial role in managing daily production activities. One key function is downtime logging, where operators write down machine downtimes and reasons on whiteboards, and shift managers then enter this information into a Power Apps-based downtime tracking application on their phones. The machine, operator initials, downtime amount and reason are provided along with the operator's comments. Because only four shift managers handle the data entry, consistency is maintained, and it's ensured that all downtime events are recorded uniformly, reducing variability in reporting. The recorded information feeds directly into Excel, allowing real-time tracking of trends and performance metrics.

The Power Apps also play into the MDI process, where shift managers use one of the apps to set daily targets during the first MDI1-level walk of the day. MDI walks are done throughout the day where the downtimes are recorded, and production progress with output numbers is being logged every two hours. This structured approach ensures real-time tracking of performance against targets.

Currently multiple different Power Apps are used to log all the different things. A new app combining close to 10 different apps was being worked on during the plant visit and is supposed to be published and taken into use during March 2025. This will allow downtime tracking, PPE (personal protective equipment) checks, 6S ratings, safety walk documenting and bin audits all to be done during the MDI walks. KPI issues and failures can also be reported directly in the app, providing a more comprehensive view of production challenges. This shift from fragmented tracking methods to an integrated system will further enable better data utilization and decision-making.

The new shift manager app also includes TECO reporting. TECO, short for "Technical Completion" in SAP, refers to the process of closing a production order after confirming that all tasks are completed. A TECO report looks at SAP data, highlighting issues like high setup or run times and high waste percentages. This report is currently being sent to the shift manager by email to answer questions like why a machine took twice as long as it should have or why there was so much waste. The shift managers used to do an MDI walk and TECO report right after each other and they were essentially reporting the same things. With the new app, shift managers can conduct TECO reports and MDI walks simultaneously, reducing redundant efforts while improving data accuracy. This integration provides better insights for long-term process improvements as the TECO reports have more proper answers.

A dashboard view is also being worked on to provide an overview of shop floor activities, allowing managers to see how everything is going with the targets, attended minutes, and overall production status at a glance. The dashboard could be implemented to include even more stats that are deemed valuable.

Shift managers also fill out shift reports on the computer with the information being based on the data that has been logged throughout the shift. These reports document key operational metrics, including marking down whether it was a "blue day". A blue day refers to a day without any accidents, near misses or other safety incidents, but it is only achieved if employees have actively done something that promotes safety. For example, this could mean spotting and removing a potential tripping hazard from the shop floor. Observations related to safety are recorded by the shift manager using Kiwa

Impact. It is marked down who spotted the issue and these can be thought of as the activities going towards a blue day. All the company's sites follow this practice and aim to achieve blue months, which are full months without any safety incidents. The approach reflects a shared company-wide focus on improving safety culture. However, across sites, defining and implementing clear guidelines for what counts as a blue activity is still a work in progress.

Process automation and improvements

One of the most significant improvements brought by Power Apps is automation in task assignments and tracking as well as internal quality control. Previously, ordering replacement parts was a slow process that took several days, as requests were manually written on paper and left in a collection box. Now, when an operator identifies a quality issue, they report it in an app for internal rejections and the shift manager approves it in their app, instantly notifying the responsible person via email. This reduces response times from a few days to just few hours.

Internal rejections are also assigned for root cause analysis, with corrective actions tracked in a separate app. Each action is appointed to the responsible personnel. Shift managers no longer need to return to their offices to raise root cause analyses but instead, they can log issues on their phones directly from the shop floor, streamlining the entire process. Corrective actions are managed through a risk priority system that assigns urgency based on cost and recurrence, with rankings from 0 to 250. The action list is visible to all stakeholders to track progress, ensuring transparency and accountability. If an issue remains unresolved for too long, automated reminders are sent via email to promote prompt resolution.

The large amount of data is the most important thing that the apps enable. Power Apps seamlessly integrates with SharePoint, Excel, and Power BI, enabling efficient data collection and analysis. The data collected within Power Apps populates SharePoint lists, which are then linked to Power BI dashboards. This integration allows stakeholders to analyze performance trends on a daily, weekly, and yearly basis. For instance, all downtime events have been logged since September 2020, creating a valuable dataset of over 70,000 entries that can be easily filtered and analyzed to identify trends and reoccurring issues.

Employee engagement and monitoring

In the UK it is allowed to track the work done by a specific operator and one of the more uncommon, yet well-received features of Power Apps is operator performance tracking. When logging downtimes and production data, the operator initials are recorded along with the machine they are working at. This data is used to monitor individual efficiency, quality, and waste metrics, showing rates for the operator in question, average of the all the operators at that workstation as well as the top scorer. Surprisingly, operators have shown a positive attitude toward this level of monitoring. Some have requested to see their own performance data to know how they are doing compared to their peers. One-on-one talks are held if there is a negative trend that can be seen from the data. The shift managers work closely with the operators so they don't only focus on the numbers but can understand factors behind the scenes that might be affecting the rates.

Their app network also supports employee upskilling and training through integrated learning modules. Operators have access to an app with various courses, including both job-related and personal development topics that the operators have suggested including technical skills and language learning. In all the courses, certificates are awarded upon completion, as this was noticed to be a crucial motivating factor to get employees to engage in continuous learning. The availability of non-work-related courses has encouraged participation, leading to increased completion of the job-related courses as well.

In conclusion, the adoption of Microsoft Power Apps has streamlined multiple aspects of operations management in the UK plant, replacing outdated manual processes with a data-driven, integrated system. By leveraging real-time data and automation, the factory continues to refine its workflows, ensuring continuous improvement and operational excellence. The system's ability to integrate with existing Microsoft tools, automate notifications, and provide real-time data insights has resulted in significant improvements in efficiency and accountability. Its impact on process standardization highlights its value as a long-term digital solution for the factory.

5.2.2 Development of the Power Apps network

The development of an app network for the plant was driven by an employee with extensive experience in the company and its operations but no prior background in programming or digital tools. Despite the steep learning curve, they found that Power Apps is only as complicated as one makes it, proving that low-code platforms empower individuals with no programming background to create functional and effective applications. Choosing the tablet layout for the apps allowed for compatibility across both laptops and phones. The phone layout was deemed less practical due to limited screen space, making it difficult to maintain a clear and user-friendly design.

The foundation of the app network is a SharePoint list with structured columns. A form can then be integrated into the app and connected to the SharePoint list as a data source. Input fields were created to correspond with the list columns, and a button was added with an OnSelect function to submit data to the list. With a few minor modifications, such as clearing and resetting form fields upon submission, a streamlined data collection process was established. To visualize the collected data, the gallery component was used, linking it as well to the SharePoint list. Similar to traditional programming, data from the list can be accessed using expressions like ThisItem.COLUMN_NAME. Editing data within the app can be done by linking a new form to the gallery component. When a user selects an item in the gallery, the form fields populate automatically, allowing for modifications. A save button updates the SharePoint list accordingly. To avoid wasting time on having to input same fields multiple times, certain fields were prepopulated, including the date, shift manager name, and a mandatory list title. The user has multiple different attributes that can be accessed through User().ATTRIBUTE. This was used to autofill user-specific fields, reducing errors and unnecessary manual input while enhancing user experience.

Copilot (Microsoft, 2025d) played a crucial role in app development, making it possible to implement a wide range of features. For users without a programming background, Copilot provides essential guidance, especially in writing if-clauses and other logical expressions, which are quite common for experienced programmers but may be unfamiliar to new users. This AI-driven support significantly reduced the time needed to grasp Power Apps functionality. Power Apps integrates seamlessly with Microsoft tools, making data management more efficient. Though SharePoint lists may not be widely preferred, they serve as the master data storage. Data can be easily exported to Excel, where recent Microsoft updates allow for seamless synchronization via refresh. Previously, Power Automate was used to transfer data to Excel, but this step is now largely unnecessary. Restricting access to the SharePoint list ensures data integrity, as only a few individuals can modify it. Excel files remain the primary interface for most employees, with the assurance that if an Excel file crashes, a new one can be regenerated from the SharePoint list.

Power Automate is employed for various workflows, such as sending emails, Teams messages, and updating files. However, automation between the app and SharePoint list is unnecessary since the connection is native. The main challenge with Power Automate is specifying exact data locations within Excel, but improvements in data refresh functionality are reducing this complexity. Teams notifications are integrated with the apps, ensuring real-time updates. For instance, when an internal rejection occurs, an automated message is sent to a designated Teams channel containing relevant details. Beyond app development, Copilot has been used for data analysis and identifying recurring issues. The seamless integration within the Microsoft ecosystem has facilitated this process. Interest has also grown in creating custom Copilots, such as a health and safety assistant that provides answers based on internal company resources.

The apps are designed to be easily understood by anyone familiar with Power Apps. However, documentation could be improved. Power Apps supports inline comments in formulas (// or /* */) and allows for comments on components or pages. With the recent introduction of coauthoring, documenting design choices should become standard practice. The speed at which apps can be developed using Power Apps is a major advantage. A new shift manager app, considered a significant development, was built in just three weeks, with only 10% of working hours dedicated to it. This demonstrates that low-code platforms enable employees to create solutions faster than outsourcing to external providers. Power Apps Studio is a dynamic environment with various built-in functions, allowing for custom logic when needed. It utilizes Microsoft Power Fx, a low-code language inspired by Excel formulas, making it accessible to those familiar with spreadsheet functions. Features such as duplicating components with automatic renaming simplify the development process.

The primary focus of the app network is tracking and reducing downtime, as it has significant implications for production efficiency and KPIs. Analyzing the data and spotting the things that are causing downtime and fixing them leads to increased productivity. They know that the operators aim to maximize production, and the operator morale rises when they have good shifts with minimal downtime. Data-driven insights support better maintenance planning, reducing unexpected breakdowns and improving operational efficiency. The development of this Power Apps network exemplifies how low-code platforms empower employees to create powerful business applications without prior programming knowledge. By leveraging SharePoint, Power Automate, and Copilot, the plant has streamlined data collection, analysis, and communication. With ongoing improvements and a strong focus on documentation, these apps will continue to enhance productivity and efficiency across the organization.

6. EVALUATION OF THE OPERATIONS MODELS

This chapter presents a comparative evaluation of the operations management practices in use at the company's manufacturing sites, based on the findings from the interviews. Each plant operates by following a shared operational structure and vision but the ways in which day-to-day operations, digital tools and improvement processes are carried out is different between the locations. This chapter examines the strengths and weaknesses of the different approaches, perceived risks and benefits of adopting a new digital tool, preferences related to development as well as the impact that the current approaches have had on workflows and efficiency. It highlights both the diversity of local practices and the recurring themes that point to broader organizational needs. The goal is to draw attention to the things that are working well but also point out where the gaps lie and what can be learned from more digitally mature sites like the company's UK plant.

6.1 Strengths and weaknesses of the current approaches

Across the case company, operational practices differ considerably from one site to another. Although some aspects including the MDI meeting framework and the use of tools like SAP or Power BI are shared, the extent and consistency of their application is very mixed. Several interviewees from the non-UK plants pointed out that while daily routines exist, their structure and quality often depend on local management or individual teams. For example, in Finland, one interviewee described that MDI1 meetings which are scheduled to take place at the machine level every morning, vary somewhat between departments, with the usefulness depending on the machine or the supervisor. "It kind of depends on the machine or department how well the meeting is actually held," the interviewee explained. This variation can affect how well the meetings reach their goal of consistently raising and solving day-to-day problems.

Another concern that was raised in multiple factories is related to the fragmented nature of the digital tools that are currently in use. Many interviewees mentioned having to go between several platforms such as SAP, SharePoint, Kiwa Impact, Power BI, and Teams, to manually extract and combine data across systems. Some employees still rely on paper printouts or handwritten notes to support morning meetings. In one interview, a manager described how they compile a morning report everyday by gathering production data from multiple sources and pasting that information into a single document to bring for discussion during the MDI round. This redundancy not only takes time but also wastes it, preventing the manager from focusing on more productive and value-adding tasks.

When it comes to handling maintenance and safety, siloed systems also present challenges. While tools like Kiwa Impact and Hupsis are actively used in safety tracking, different interviewees noted limitations in their usability and in how effectively they support follow-up. Maintenance reporting tends to happen in a manual or Excel-based system, without much transparency between production and maintenance teams. This has led to situations where operators do not know whether a machine has been worked on, which in turn can affect production and safety.

In spite of these limitations, employees across different factories have demonstrated a proactive attitude toward problem-solving and continuous improvement. Multiple sites have developed their own workarounds and self-built tools to fill in the perceived gaps in the existing systems. As much as this shows adaptability and initiative, it also reinforces the divide between factories by continuing to use locally optimized, but globally inconsistent, processes. What becomes to light is a missing common digital infrastructure that would support more aligned operations in all the different plants of the company.

At the UK plant, while the current system with the apps has proven effective, there are some areas that could be improved. For instance, there is some duplication of work, as operators could log downtime directly into the app themselves. However, it has been explained that having shift managers handle this task ensures they spend more time on the shop floor rather than sitting behind a screen, which can be beneficial for overall oversight and engagement. Additionally, this keeps the reporting style consistent.

Some concerns have been raised about the number of messages being sent across different platforms and feeling like the correct information is difficult to find. However, the system is designed so that notifications are only sent to the relevant individuals, reducing unnecessary communication overload, and the messages should be easy to find from the specific Teams channels.

One of the key challenges in expanding the use of the UK-developed apps to other countries is language differences and variations in operational practices. What is considered essential in one plant may be irrelevant in another. This raises the question of whether harmonizing work processes across different locations would be beneficial.

Standardizing certain procedures could not only improve efficiency but also enable better data collection and comparison across sites.

These observations from the UK plant highlight a level of maturity and integration that is currently not seen at the other sites. The ability to have consistent and relevant notifications, maintain reporting, and keep managerial roles actively involved on the shop floor has contributed to smoother daily operations. However, the broader organization still faces challenges with aligning local processes, varying levels of digital tool adoption, and ensuring better cross-functional visibility. These differences suggest that aligning some core practices could help the organization address shared challenges more effectively and make it easier to transfer useful knowledge between sites, without requiring complete uniformity.

6.2 Risks and benefits of adopting a new digital tool

At sites that still rely on manual or only half-digital systems, one of the most common risks associated with adopting new digital tools is the fear of overcomplicating workflows that are heavy to begin with. In several interviews, users were reluctant to add new systems to the mix unless they clearly replaced existing tools and made daily work easier. There is also doubt at some sites about the long-term support for new tools, especially if local IT resources are limited or if only too few people had knowledge about the tools. As one interviewee at a Finnish plant pointed out, some the tools they currently have are the result of personal initiative, and there is concern that these would be overlooked or replaced during a larger transition. Given the fragmented environment and different local adaptations, it is likely that not all existing workarounds can be incorporated into a new solution so some level of discontinuity might be unavoidable.

At the same time, employees also recognized the current limitations. Interviewees in China, Italy, and the Netherlands all mentioned that the communication between maintenance, production, and quality teams could be improved if data was better centralized and accessible. Some pointed out that although SAP is widely used, it is not always intuitive or user-friendly and often requires users to “know where to look,” which has hindered broader adoption. “You have to memorize everything to know what to press, otherwise you really can’t get anything done,” said one interviewee, highlighting how system complexity limits usability for many employees. There was a consistent desire for tools that were more visual, possibly mobile-friendly, and easy to use, especially for shop-floor operators who may interact with complex systems on a regular basis.

The shift to new digital tools has provided valuable insights by allowing employees to validate their gut feelings about potential problems with data-backed evidence. This transparency is especially noticeable in real-time data transfer, where issues like certain production rejections are communicated almost immediately, eliminating days of unnecessary waiting. These rejections are specific to the company's manufacturing processes and occur when items fail to meet internal quality standards. This real-time feedback has proven to be a major benefit in keeping everyone informed.

A surprising outcome was the positive reception from operators, who preferred using apps over Microsoft Forms. Since many operators are already familiar with smartphone apps, the interface felt intuitive and accessible, like something they use in their everyday lives. This reflects findings by Ajimati et al. (2025), who note that visual design and mobile-friendly layouts in low-code apps significantly improve user acceptance among non-technical personnel. The operators even began suggesting additional features to improve the apps, leading to the development of tools that are now used regularly. While some apps are more popular than others, the ease of building them means it hasn't been a burden to experiment. This flexible approach allows the team to try out new ideas and stick with what proves useful in day-to-day operations.

Another significant benefit is the amount of data now available for Continuous Improvement (CI) managers. The ability to track KPI failures by specific job numbers has made it easier to identify recurring issues, such as excessive waste percentages. By analyzing these trends, CI teams can take targeted actions to reduce downtime, improve production efficiency, and minimize waste. With a larger pool of data being collected, the CI team is now able to spot patterns and trends that were not apparent before. Gu et al. (2023) found similar results, highlighting that real-time KPI data enables faster, more targeted improvements in manufacturing environments.

There have been concerns from some employees from the other factories related to only a few individuals possessing the necessary knowledge for maintaining and handling the apps. However, this has not been a problem at the UK plant, where a select group has access to the tools and another group is being trained to help build apps. This approach ensures that knowledge and skills are distributed without overwhelming a single team member.

At higher levels, those in charge have full control over the apps and Power Automate flows, including the ability to add or revoke access rights. For example, if a flow is causing issues like sending out frequent organization-wide emails, they can quickly shut it down to prevent further disruption. This process is managed through Microsoft's

Center of Excellence (CoE), which ensures that all flows and apps follow certain naming conventions that allow for good traceability. This system helps maintain control and oversight, ensuring any problems that arise can be easily addressed.

Even though the UK example has demonstrated what is possible when digital tools are user-centered and when they have appropriate governance structures, there are still many factories that remain hesitant. Some interviewees expressed concern over ownership and sustainability: if a tool breaks or fails, who is responsible for fixing it? Or if a developer leaves, how is that knowledge preserved? Many interviewees expressed a need for more formalized support structures that are both technical and organizational, before they could see a broader adoption feasible.

However, even the most cautious interviewees agreed that the current status quo is unsustainable. The lack of integration between tools, the inefficiencies of manual reporting, and the inconsistencies in how issues are followed up, all contribute to a lot of operational friction. The UK site's experience offers a compelling counterpoint, demonstrating how with the right foundation, digital tools have the potential to improve transparency, empower users, and support data-driven decision-making at all levels of the organization.

6.3 Outsourcing vs. in-house low-code development

Digital maturity, available expertise, and organizational culture at each site all affect the differing opinions across the company about the best way to manage app development. While the UK factory has had success developing Power Apps internally, interviewees from other locations expressed hesitation about adopting a similar approach. The main reason that was mentioned is the lack of personnel with the time or technical background to engage in app development. One interviewee noted that even working with Power BI had led to questions about ownership and reliability, suggesting a broader concern with internal capacity and the potential burden of technical responsibility. Others stated a preference for ready-made tools and expressed concern about who would ultimately be responsible for maintenance or troubleshooting in an internal development model.

App development was viewed by one participant from the UK site as something that should be handled internally. The primary reason for this is the speed at which a functional app can be created. When the requirements are already clear, it is much quicker to build the app in-house rather than explaining the needs to an external developer. Additionally, keeping development internal is more cost-effective, as it eliminates the need to continuously pay for new apps within the network. This also allows for temporary data collection and experimentation, giving teams the flexibility to test different features and determine what is most useful.

It was also stressed that managing the apps effectively would require more than just one person. One suggestion was to have one dedicated individual per site who can handle local issues and change requests. If a single person were responsible for all locations at a group level, they would quickly become overwhelmed, as different factories inevitably have unique requirements. According to this view, training someone at each site to develop the apps would not be difficult as long as they have the interest and willingness to learn. Although there is already an existing RPA (robotic process automation) team, there was openness to the idea of expanding or refining the team structure. This could include hiring someone with programming experience and knowledge of Power Apps to assist with development. To ensure scalability and efficiency, one suggestion is to consider a more defined structure within the RPA team, with some members focused on integrating the apps with other software and others dedicated to their development.

This proposed approach was echoed to varying degrees in the other interviews. In Finland, for example, it was suggested that localized development could potentially work, especially since many employees are already familiar with tools like Excel and SharePoint. However, concerns were raised about whether there would be enough motivated and technically skilled people who could take on development roles without additional support or clear incentives. The idea of having a dedicated developer or a so-called power user per site was seen as ideal but possibly unrealistic without structural changes. One interviewee also expressed frustration with manual data handling and thought that apps like those in the UK would be valuable but noted that site-level development would be difficult due to limited expertise and time constraints. They emphasized that any new tools would likely need to be introduced and maintained centrally, with local customization handled in a guided way.

One challenge with scaling the apps company-wide has been the level of motivation in other countries to implement them. Technically, adapting the apps for different locations would not be difficult. For example, a SharePoint list can be created from an existing Excel file, and most plants likely already maintain their data in spreadsheets. If those files were in the local language, the language barrier would be eliminated, and plants could track only the metrics they find relevant. However, the main obstacle seems to be that many employees prefer fully developed, ready-to-use apps rather than investing effort into adapting them.

In sites where app development or customization is not currently happening, there was some openness to a hybrid model where the apps could be developed centrally but configured locally. For instance, one interviewee underlined that the digital tools must adapt to the “language and rhythm” of the local production environment, warning that that solutions that were designed elsewhere may not automatically fit. Still, there was agreement that if the apps were simple, user-friendly and already integrated with existing systems (like SAP or Power BI), adoption would be much easier.

At the UK site, the scalability of Power Apps has generally been viewed positively. No significant limitations have been encountered that would prevent these apps from being implemented in factories of different sizes. The apps can accommodate as many users as needed and function seamlessly on both mobile and desktop devices. Load testing with multiple users accessing the same app simultaneously has not revealed any performance issues.

A concern raised about outsourcing development was the potential loss of control. In most cases, outsourcing would mean that the company’s data is stored on an external cloud database, limiting direct access. Additionally, customization and adapting the apps to new machinery or processes would require extra costs, making long-term reliance on external developers an expensive solution. An interviewee estimated that outsourcing would take three times as long to deliver the desired results compared to handling it internally. As an example of the downsides, Kiwa Impact is mentioned as a software the company pays for but does not find useful, as it has failed to meet expectations despite multiple requests for changes.

This frustration with externally managed systems was reflected in other interviews as well. Kiwa Impact was described as rigid, unintuitive, and slow to adapt to user feedback. These complaints made a strong case for in-house development as a way to retain control and responsiveness. However, some interviewees also voiced concerns about “shadow IT” so situations where apps are built quickly by individuals without proper oversight, long-term planning, or shared visibility.

This aligns with research on citizen development, which highlights the need for scalable governance. While low-code platforms empower non-developers to build solutions quickly, studies have shown that without clear guardrails, these efforts can result in inconsistent practices and duplicated efforts across departments (Hoogsteen & Borgman, 2022). For in-house low-code to be sustainable, the organization must proactively define approval workflows, shared component libraries, and role-based access. This ensures that apps built by non-developers align with security standards, organizational data policies, and long-term maintainability. Without these measures, the risk of fragmentation increases, especially as the number of citizen developers grows (Overeem & Jansen, 2021).

At many sites, concerns about in-house development include questions regarding who would be responsible for maintaining and troubleshooting the apps, as well as the long-term sustainability of these solutions. There was worry about what would happen if a developer left or if significant updates were needed after years of use. A few interviewees highlighted that undocumented tools, even internally built ones, can lead to knowledge silos and make systems fragile. While in-house development is seen as flexible, several interviewees said that it must be supported by solid governance structures and documentation practices to prevent tools from becoming invisible systems like so many local workarounds already in use.

The UK site, however, does not share these concerns. Based on their experience, maintenance has not been a major issue. Most of the issues they have encountered so far have been related to modifications rather than ongoing maintenance or daily upkeep. Once an app is functional, it tends to run smoothly. The only recurring technical problems have been with Power Automate flows, which occasionally fail due to users entering incorrect formats or other minor errors. These failures occur roughly five times a year and are generally quick and easy to resolve. This has given the UK team confidence in the manageability and reliability of their tools.

When it comes to Power Apps versus traditional programming, interviewees at the UK site did not express a strong preference, as they lacked experience with traditional software development. They were open to both approaches if the company were to hire a developer. However, if development remains within the existing team, Power Apps is the more practical choice, as most employees are already familiar with the Microsoft 365 environment. Regardless of whether the apps are adopted company-wide, there was a clear intention to continue using them locally, as they were seen to bring concrete value to daily operations. The positive experiences at the UK site reflect not only satisfaction with the tools themselves, but also a sense of pride in having created solutions that genuinely improve their own work.

One potential challenge with in-house development is that architectural decisions and best practices might not always be carefully considered. Since Power Apps is built using a drag-and-drop interface with a constantly visible UI, there is less focus on the underlying structure. While this simplifies development, some aspects of the current app structure may not be the most efficient. This could be a result of citizen development, where the priority is functionality rather than optimization. Another consideration is ensuring that the apps are designed in a way that allows for easy modifications in the future. If not built with scalability in mind, changes may require extensive rework, leading to inefficiencies. Addressing this may require developers with prior programming experience or a more structured approach to app design to prevent unnecessary duplication of effort.

To summarize the key considerations discussed in the interviews, Table 3 presents a comparison between outsourcing and in-house development of low-code applications. The table highlights key factors such as speed, cost, control, and scalability, based on practical experiences across sites.

Table 3. *Outsourcing vs. in-house development*

Aspect	**Outsourcing**	**In-house development**
Speed	Slower due to need for specification handoffs and iterative feedback cycles	Faster when requirements are clear, avoids delays in external communication
Cost	Higher long-term cost, each update/customization incurs additional fees	Lower long-term cost, no repeated payments for new apps
Control	Limited control, data may be stored externally, customization may be restricted	Full control over data, design, and adaptability
Expertise required	Less internal training needed, but relies on external expertise	Requires internal motivation and upskilling at each site
Maintenance	Dependence on external vendor, potentially slow response to fixes or updates	Manageable with proper support structure (e.g., one power user per site)
Scalability	Scaling across sites may involve additional costs and coordination challenges	Flexible and proven at UK site, apps can be scaled to other locations easily
Data security	Must trust external party with sensitive data	Data stays within the company's infrastructure
User motivation	Reduces burden on internal staff but may lower sense of ownership	Depends on local willingness and digital maturity

Ultimately, the choice between outsourcing and in-house development does not need be viewed as binary. Different sites may benefit from different approaches, depending on their capabilities, needs, and context. The UK model provides a clear example of what is possible when internal development is empowered, but it also underlines the need for broader alignment if that kind of model is to succeed across the organization as a whole.

6.4 Impact on workflows and efficiency

Across the case company's factories, the efficiency of workflows and clarity of communication are handled in notably different ways. As previously noted, many sites follow similar operational frameworks with the MDI meetings and regular audits. However, the tools supporting these activities often vary widely in quality, accessibility, and integration. In factories where digital tools are underutilized or fragmented, much of the communication continues to rely on verbal reminders, shared spreadsheets, and manual logging, contributing to inefficiencies such as forgotten tasks and difficulty maintaining consistent follow-up. In contrast, the UK factory has experienced measurable improvements in workflow reliability through the systematic use of the developed apps and automations.

At the UK plant, it was noted that the introduction of the apps has significantly improved workflows. One participant, who had previously worked at the company before these tools were available, has noticed a clear improvement in task management and the overall way of working. One major improvement is the integration of PPE checks and 6S ratings into the MDI walk app. While these have always been a part of the shift managers' responsibilities, they were not consistently carried out. Now that they are incorporated into the app, shift managers must complete them by filling in the required sections, ensuring greater accountability. The apps also streamline communication and task delegation among shift managers. Previously, responsibilities such as checking in with an operator that everything is alright relied on verbal communication, which could lead to tasks being overlooked. Now, actions can be recorded and shared, allowing any shift manager to step in and complete pending tasks, ensuring continuity. This aligns with research by Ajimati et al. (2025), who emphasize that low-code platforms enhance operational communication by embedding task status, ownership, and automated reminders directly into workflows.

The real-time nature of low-code-based daily management systems also contributes significantly to workflow efficiency. In the case of the UK plant, shift managers benefited from integrated reporting and automated alerts that eliminated delays previously caused by manual processes. A similar outcome was observed in the implementation by Gu et al. (2023), where real-time KPI evaluation enabled faster decision-making and production optimization. These kinds of systems not only digitize the existing workflows but also enhance them. Automation, data integration, and visualization are essential for sustaining lean and responsive manufacturing environments (Gu et al., 2023).

Another key improvement is the automation of communication through Power Automate. In the past, employees sometimes claimed they had not received important emails, but automation ensures that all necessary information is sent automatically, with data to verify delivery, eliminating miscommunication. Additionally, each person logs their completed actions personally, which adds transparency as unresolved problems will always resurface if they are not properly addressed. This removes any possibility of someone falsely claiming an issue was handled when it was not. The team has found that this method of tracking corrective actions is more effective than previous approaches, where they were stricter and going around to talk to people in person in order to track who has done what. The new method fosters accountability without excessive oversight. Overall, these digital tools have made workflows more efficient, transparent, and accountable. This method supports the findings of Pinho et al. (2023), who found that low-code tools with built-in audit trails and personal accountability features promote transparent workflows with less need for managerial micromanagement. However, as Domański et al. (2023) caution, the effectiveness of these systems depends on structured implementation. Without clear guidelines, even low-code platforms can result in fragmented communication or over-automation.

In contrast, multiple interviewees from other factories described a less structured environment. In some cases, task follow-ups still depend on email chains or shared Excel trackers, which are vulnerable to being forgotten or ignored if no one is actively monitoring them. One Finnish interviewee noted that the systems in use are fragmented across three overlapping platforms that do not integrate with one another, making it difficult to maintain a consistent daily workflow. Interviewees also noted that while issues are discussed in MDI meetings, the outcomes are not consistently recorded in shared or visible systems, making follow-up difficult across shifts. In some plants, tasks or actions are assigned verbally and depend on individuals remembering to follow up. This reliance on memory and informal communication highlights a clear difference compared to the UK site, where app-based tracking ensures that no issue is silently dropped.

These differences in workflow tools and practices highlight how the presence or lack of digital systems can significantly affect operational consistency. Although every site aims for efficiency and continuity, the UK factory demonstrates how digital platforms can align expectations, close communication gaps, and reduce dependence on individual habits. These improvements also promote a more proactive and transparent work culture without requiring strict top-down enforcement. When the other sites consider adopting similar digital tools, it is essential to focus not only on technical implementation but also on embedding these systems into daily routines in a way that encourages behavioral change and supports lasting improvement.

7. DEVELOPMENT OF OPERATIONS MANAGEMENT

This chapter focuses on how operations management tools can be developed, adopted, and integrated in a way that supports both daily routines and broader organizational goals. Based on the interview findings and practical experiences, the chapter outlines key lessons related to tool design, integration, user adoption, and change management. It examines both successful development efforts and the practical challenges encountered at various factories, where differences in system usage, available resources, and digital readiness have influenced the ease of implementation. The chapter also explores the organizational conditions that support or hinder adoption, from training strategies to the role of motivation and leadership in encouraging sustained use. In addition, it includes a summary of expectations that employees across different sites have for future systems and an evaluation of available software platforms. Together, these findings help identify what makes a digital tool effective in the operations context, and what factors must be considered to scale solutions across a global manufacturing network.

7.1 Tool development and integration: what worked and what to watch for

Implementing the new app network at the UK site required careful planning to ensure long-term usability and adaptability. It was driven by a clear goal of wanting to create digital tools that would not only replace the existing processes but become an integrated part of daily operations. Since processes and tracking requirements evolve over time, the apps were designed with flexibility in mind. The structure allows for easy modifications, making sure that removing or changing certain elements does not disrupt overall functionality. For example, the MDI walk checklist includes items like PPE checks at the beginning, which they know will always stay, while newer elements, such as the tracking of the purple bin, are positioned later in the list so they can be removed if necessary.

A key enabler of successful integration was usability and to maximize it, the apps were designed with operators in mind. Simplicity was a priority, reducing the need for extensive training. Instead of requiring manual text input, the apps use dropdown menus and radio buttons wherever possible, minimizing errors and making data entry faster. This design choice not only improved user experience but also ensured consistency and reliability in the data collected. For example, when logging downtime reasons, operators select from a predefined list of common causes specific to each machine, with an “other” option allowing for additional input if necessary. This list is updated as new recurring issues emerge and can be spotted from the data. This approach aligns with Pinho et al. (2023), who emphasize that intuitive interfaces are essential for the successful adoption of operational applications in manufacturing environments.

Instead of formalized user experience studies, testing focused on practical use cases to make sure that the apps worked smoothly in typical and edge-case conditions. The team manually tested extreme scenarios to check the system’s reliability and also conducted a two-week so-called beater phase before the full rollout. Given the relatively simple logic behind the apps, no significant technical issues have arisen since deployment. Over three years of use, all reported problems have been linked to incorrect data input rather than system failures.

Although no structured user testing was conducted, there hasn’t been any negative feedback which would suggest that the apps meet operational needs. Their design prioritizes functionality over appearance, but efforts have been made to maintain a standardized look across all applications. Continuous improvements are made as the developer gains more experience. However, one potential concern is that, with a single person overseeing all aspects of development, it is possible that certain usability issues go unnoticed. Operators and shift managers, who haven’t previously used any similar digital tools, may simply adapt to the system rather than identifying areas for improvement. In future development, incorporating some form of usability testing could ensure that the apps evolve in a way that best serves their users.

Experiences from other factories in the group highlight several pitfalls that the UK site has managed to avoid. In many cases, integration efforts have been hampered by fragmented systems and disjointed data flows. Interviewees from Finland, China, and Italy described environments where safety audits, maintenance logs, and production data are all recorded in separate platforms which are often Excel, SharePoint, or paper. These silos require constant manual input, copying data between systems, and increase the risk of oversight or miscommunication.

For example, in China, MDI meetings require data to be compiled manually from different sources before it can be presented on a digital board. In Finland, safety and production tools exist in parallel but don’t interact, resulting in extra steps and uncertainty over task ownership. In Italy, simple Excel trackers and calendar tools have been adopted, but they lack the automation or visibility needed for broader accountability. These fragmented setups may work locally, but they do not scale well and often collapse under staff changes or increased complexity.

A recurring theme across these sites is that digitization efforts too often replicate paper processes without addressing the underlying pain points. Simply replacing a checklist with a digital form doesn't solve the problem if the data still needs to be copy-pasted or manually compiled. True integration means automating notifications, reducing duplication, and linking operational areas that were previously siloed. In this sense, technology must not only digitize but also restructure workflows to support better collaboration and visibility.

These examples underline that successful integration is not just about flexibility or functionality. It is about creating systems that actively reduce manual work, eliminate information silos, and make data visible to the right people at the right time. A well-integrated tool should do more than digitize a checklist. It should automate communication, link related workflows, and support accountability across shifts and departments. To avoid common pitfalls, future efforts should focus on designing tools that are simple to use, adaptable to evolving needs, and embedded within existing operational routines. Just as importantly, integration should be seen not as a technical task alone but as an organizational one where clarity, consistency, and cross-functional input are key to long-term success.

7.2 Organizational considerations: training, adoption, change management

In terms of resistance, there were no significant issues related to learning how to use the apps. Most users were open to learning new tools, and the apps themselves did not pose a problem in that regard. Most of the resistance encountered was related to the increase in accountability with having to complete tasks they were technically already responsible for. The apps function as a support tool to make sure that all required actions are carried out, which can feel like added pressure. While it would theoretically be possible for someone to falsely confirm a completed task, over time that would cause problems, and no one has been willing to take that risk, so it hasn't been an issue.

In terms of adoption, it was emphasized that having someone on-site should is important to ensure a smooth rollout. Working closely with operators and shift managers is crucial as it usually takes multiple rounds of training and hands-on guidance before users feel fully comfortable and confident in using the apps effectively. The goal is to ensure that all users not only know how to use the apps but understand how they help structure daily tasks. Having local support available during this learning period was helpful in practice, especially when users come across unfamiliar or unexpected situations.

Training was not a significant challenge, as the necessary skills are easy to pick up when there's genuine interest and willingness to put in the effort. However, this raises the question of how to better spark that interest. Involving people early in the process, showing how the apps can solve real problems in their day-to-day work, or simply giving them time to explore the tools at their own pace could all help increase motivation and lead to smoother adoption.

Interviewees from other sites pointed out that when it came to adoption, motivation and perceived usefulness were often identified as more significant barriers than technical complexity. Some participants described cases where MDI routines had faded not due to the tools being difficult to use, but because employees did not see clear value in them or lacked follow-up from managers. This highlights how change management must go beyond training sessions, and it should include ongoing coaching, visual feedback on results, and reinforcement from leadership which demonstrates commitment to the process.

Another recurring theme was the want for ready-made tools. While the UK team embraced the flexibility of building their own tools, other sites expressed a preference for off-the-shelf solutions that are immediately useful without requiring extensive adaptation. This suggests that adoption strategies should be tailored for each site’s level of digital readiness. In some locations, providing ready-to-use templates along with centralized support may help lower the adoption barrier, while in others, enabling on-site experts and encouraging experimentation may lead to better outcomes.

Overall, the UK rollout shows that successful adoption is less about technical training and more about building motivation, support, and ownership. The key is not just teaching users what the tool does but helping them see why it matters in their context as well as ensuring they have someone nearby to help them through the transition.

7.3 Interviewee expectations for a future system

Across every site, interviewees expressed a range of expectations and hopes for a future operations management system. While local practices differed significantly, there was a common wish for tools that would better support efficiency, visibility, and accountability in daily operations.

A recurring theme was the requirement for integrating currently fragmented systems. Interviewees reported that information related to safety, maintenance, production, and quality is spread across different tools like Excel, SharePoint, SAP, or paper forms, and it is both time-consuming and error-prone to track and follow-up. A future system was expected to bring together these workflows and provide real-time visibility across teams. This would help with continuity across shifts and departments and reduce duplication as well as manual entries.

Another frequently mentioned requirement was the ease of use, particularly for shop-floor employees who may not be used to using digital tools in a work context, even if they are comfortable using tech in their personal lives. Interviewees highlighted the importance of intuitive interfaces with minimal typing, dropdown menus, and mobile compatibility. This was reflected in the UK rollout, where the positive response to the Power Apps tools was largely tied to their simplicity and familiarity, which made broader adoption easier without extensive training.

Several interviewees pointed out the need for real-time feedback and visual confirmation. For example, one suggestion was for machines to display a clear visual signal once scheduled maintenance is completed and checked. Others wanted dashboards that could show the status of open actions or recurring issues in simple, visual formats. These kind of features were seen as essential for fostering transparency and accountability without the need for heavy oversight.

Language support and built-in guidance also came up repeatedly. While employees were used to working with English-language tools, they expressed a clear preference for having systems available in their native language. In some cases, resistance to digital tools was linked more to unfamiliar terminology than to technical difficulty. Interviewees suggested that offering local language options and role-specific views could help to improve accessibility, reduce misunderstandings, and encourage consistent use across teams.

Interviewees were also interested in systems that could have forward-looking capabilities and more advanced functionality, such as predictive maintenance alerts or automated reporting filters that could flag unusual patterns in production or waste data. Several highlighted that future systems should support better knowledge retention by making it easy to store and retrieve documents, link them to specific jobs or equipment, and improve handovers.

Altogether, these expectations reflect both frustration with current systems and a clear vision for a more connected, transparent, and user-friendly way of managing operations. A key takeaway is that future solutions must be flexible enough to work in different cultural and organizational contexts while still promoting alignment and consistency across the company.

7.4 Evaluation of available platforms for the case company

While Section 3.2 provided a general comparison of leading low-code development platforms based on academic and technical literature, this section focuses on evaluating those platforms in the specific context of the case company. The goal is to determine which option best supports the company's operations management needs, considering factors such as system compatibility, usability for non-technical staff, cost efficiency, and scalability across multiple manufacturing sites. The evaluation draws on both the interview findings and the company's existing digital infrastructure to ensure that the recommendation is grounded in practical relevance rather than theoretical preference.

The digital tool proposed for improving operations management must be scalable, user-friendly, cost-efficient, and compatible with the case company's existing IT environment. Based on the needs that were identified during the interviews, including ease of use, support for multiple sites and languages, integration with existing Microsoft tools and low development overhead, the focus of this evaluation is on low-code development platforms. These platforms offer a balance between customizability and speed of deployment, and they are accessible to both professional developers and non-technical users.

While fully custom-built software could theoretically provide the highest level of flexibility, it also requires significantly more time, resources, and specialized programming expertise. Custom systems typically involve higher development and maintenance costs, longer implementation cycles, and increased dependency on external vendors or in-house developers. For a multi-site organization seeking fast deployment and adaptability across teams with varying levels of digital maturity, this option would likely be unsustainable. Therefore, custom-coded tools were excluded from the primary comparison, although they remain a possible solution for niche cases in the future.

Another viable path would be to adopt off-the-shelf software already designed for daily operations management, such as audit and task tracking platforms or manufacturing-focused systems. Several such tools were already in use at the company, including Kiwa Impact and InstaAudit. While these tools provide structured workflows and compliance features, interview feedback indicated several drawbacks: poor adaptability to evolving factory processes, limited user configurability, and inconsistent usability across sites. Additionally, none of the existing vendor tools were adopted uniformly across factories, often due to licensing complexity, slow onboarding, or lack of local language support. For these reasons, off-the-shelf vendor solutions were not selected as the preferred option.

Unlike these vendor systems, low-code platforms offer a higher degree of flexibility, allowing rapid adjustments to process flows without needing third-party changes or negotiations. This enables faster experimentation, localized problem-solving, and user-driven innovation. In fast-changing production environments, this adaptability is particularly valuable.

To ensure an objective selection process, four low-code platforms were analyzed based on publicly available documentation, academic literature, and case-specific criteria: Microsoft Power Apps, OutSystems, Mendix, and Zoho Creator. These platforms were selected due to their presence in the market and their relevance in the literature review presented in Section 3.2. Table 4 below summarizes the key characteristics of each platform based on those findings.

Table 4. *Comparison of available low-code development platforms*

Criteria	Power Apps	OutSystems	Mendix	Zoho Creator
Integration with Microsoft tools	Excellent (Excel, Teams, SharePoint, Power BI)	Broad API support, weaker native MS links	Good (via Siemens & REST APIs)	Limited beyond Zoho ecosystem
Usability for non-developers	High (especially for O365 users)	Moderate	Moderate to high	High (simple UI, easy forms)
Licensing / cost model	Included in many Office 365 plans	Enterprise-tier pricing, higher cost	Moderate enterprise pricing	Lower cost, flexible pricing
Customization potential	Moderate (custom connectors possible)	Very high (Java/.NET-based)	High (Microflows + Java/JS)	Moderate (Deluge scripting)
Suitability for case company	High	Moderate	Moderate	Low to moderate

As described in Section 3.2, these platforms differ significantly in design philosophy, integration scope, and customization potential. Power Apps stands out for its tight integration with Microsoft's ecosystem, which is already heavily used across the case company's sites. Its familiar Excel-like formula syntax and Office 365-native environment make it highly usable for non-technical staff. OutSystems and Mendix offer more advanced customization capabilities through coding extensions (Java, .NET, Microflows), making them strong options for complex enterprise applications, though this comes at the cost of higher complexity, pricing, and steeper learning curves. Zoho Creator, on the other hand, is designed for simplicity and rapid development, but lacks the integration depth and enterprise-grade robustness needed for a multi-site manufacturing context.

This section now turns to a deeper evaluation of not only return on investment, cost-efficiency, and integration capabilities, but also practical deployment considerations such as offline access, mobile usability, version control, and support infrastructure. These operational factors are especially important in the context of multi-site manufacturing environments and help further differentiate the platforms.

From an investment standpoint, low-code platforms like Power Apps offer significant advantages in terms of both development time and long-term cost. Automating a single recurring task, like weekly safety inspections or downtime reporting, using Power Apps can reduce manual data entry, improve data accuracy, and eliminate versioning issues. According to a Forrester study commissioned by Microsoft, organizations using the Power Platform reported an average 25% reduction in time required to complete key business processes after implementation (Microsoft, 2025g). Across multiple sites, this represents a substantial reduction in time and labor costs.

The total cost of ownership (TCO) for low-code apps is also lower than that of custom-built or vendor-licensed platforms. Power Apps development can often be performed in-house without high developer salaries, while enterprise licenses for Microsoft 365 already cover many of the needed features. In contrast, commercial operations management software often involves high setup costs, annual maintenance fees, and lengthy onboarding periods. A comparative experiment by Aveiro et al. (2023) demonstrated that building an application with a low-code platform required only 47.5 hours of work, compared to 888 hours using traditional development method which is a reduction of over 94%. This suggests that low-code solutions can significantly reduce both development effort and long-term cost, making them a financially prudent option for the case company (Aveiro et al., 2023).

Another key factor in the platform evaluation was integration flexibility, particularly the ability to work across both cloud and on-premise systems. Power Apps, along with tools like Power Automate and Dataverse, supports robust API connectivity, enabling the integration of data from sources like SharePoint, SAP, SQL, and Excel. While platforms like OutSystems and Mendix also offer integration, they often require more technical configuration, and their native support for Microsoft ecosystems is weaker.

In terms of real-time data synchronization, Power Apps can utilize connectors and gateways to sync cloud-based app data with on-premise environments. This makes it suitable for hybrid manufacturing setups, where data needs to move securely between factory-floor systems and cloud dashboards. While off-the-shelf vendor platforms may support real-time syncing, they typically lock users into proprietary data models, limiting flexibility and increasing long-term dependency on the vendor.

Beyond technical capabilities and cost factors, several operational concerns influence the suitability of a low-code platform for deployment across manufacturing sites. These considerations play a crucial role in the platform’s usability, manageability, and scalability in practice.

Offline functionality is one important requirement for certain factory settings with unstable or limited internet connectivity. Power Apps offers offline capability through its canvas apps by enabling data caching and delayed synchronization (Microsoft, 2025b). This allows users to interact with forms or record data locally on a mobile device and sync with cloud-based systems once a connection is re-established. However, implementing this feature requires deliberate planning and configuration and may be more complex in apps that depend heavily on real-time data or external APIs. By comparison, Mendix and OutSystems also support offline-first mobile apps, often with more sophisticated native support, but typically require more development effort and a stronger IT skill base (Mendix, 2025d; OutSystems, 2025c). Zoho Creator provides basic offline access, but with limited control over sync rules and less flexibility for complex use cases (Zoho, 2025c).

Mobile responsiveness and usability are valuable features that enable the use of tablets and smartphones on the factory floor, supporting more flexible and accessible workflows. Power Apps provides responsive layouts, especially for canvas apps, and supports both iOS and Android through the Power Apps mobile app (Microsoft, 2025c). While functionality is generally consistent across devices, there can be limitations when switching from desktop to mobile, especially if the app is not designed with adaptive controls in mind. Therefore, mobile-first design should be considered during development. OutSystems and Mendix offer more advanced mobile frameworks and responsive layout control out of the box, particularly suitable for performance-critical or highly customized apps (OutSystems, 2025e; Mendix, 2025e). However, they come with a steeper learning curve. Zoho Creator, while mobile-compatible, is best suited for simpler apps with basic interface requirements (Zoho, 2025b).

App lifecycle management and version control are managed within the Power Platform admin center. IT departments can oversee environments, deploy updates, roll back changes, and control user access through integration with Azure Active Directory (Microsoft, 2025a). Versioning is supported, and changes can be published without disrupting active users, provided the apps are built with modular design and proper testing workflows. Mendix and OutSystems provide even more extensive DevOps and lifecycle tooling, including automated testing environments, CI/CD pipelines, and team-based development tools (Mendix, 2025a; OutSystems, 2025a). These are advantageous in large enterprise IT settings. In contrast, Zoho Creator offers only basic version control and role management tools, which may not scale well for complex or distributed teams (Zoho, 2025a).

Training and support availability is another practical strength of Power Apps. Microsoft provides a comprehensive learning platform (Microsoft, 2025f), an active community forum, certification programs, and a broad ecosystem of implementation partners. This ecosystem supports internal upskilling as well as access to external expertise, which is especially helpful as the platform scales across additional factories. Similarly, both Mendix and OutSystems offer well-developed learning paths, partner networks, and certifications (Mendix, 2025b; OutSystems, 2025d). These platforms are often favored by larger organizations with centralized IT support. Zoho Creator, while easy to use, has a smaller developer community and more limited enterprise support infrastructure (Zoho, 2025e).

Overall, Power Apps offers the necessary infrastructure and community support to sustain long-term operations across a distributed industrial environment. While it may not match the full enterprise tooling of Mendix or OutSystems, it provides a strong balance of accessibility, extensibility, and control. Compared to Zoho Creator, which while easy to use, lacks enterprise-grade features, Power Apps is better suited for large-scale, multi-site deployment in the case company's context. Taking both technical capabilities and practical deployment factors into account, Microsoft Power Apps appears to be the most suitable option for the case company at this time, based on four key criteria:

1. System compatibility: It integrates seamlessly with existing tools already widely in use across sites, such as Excel, SharePoint, and Teams. This reduces onboarding friction and leverages existing licenses and digital infrastructure.

2. User accessibility: The Excel-like formula system and visual interface align well with the company's aim to empower users who may not have formal programming backgrounds.
3. Scalability: Power Apps has already proven effective in one site and can be deployed gradually to other factories with minimal disruption, while allowing for local customization through a centralized framework.
4. Cost-efficiency: The platform is included in most enterprise Microsoft 365 plans already in use by the company, making it financially accessible compared to high-cost platforms like OutSystems. Moreover, it supports rapid automation of manual processes, potentially reducing hours of repetitive work per week and improving data accuracy. Compared to off-the-shelf vendor tools like Kiwa Impact, which were often described in interviews as rigid or non-scalable, Power Apps offers a lower total cost of ownership and greater flexibility.

While OutSystems and Mendix offer more flexibility and enterprise-level extensibility, they introduce greater complexity and cost that are not aligned with the company's current needs. Zoho Creator, though simple and affordable, may not provide the necessary robustness or integration depth for a multi-site manufacturing environment, nor does it handle hybrid cloud/on-premise environments as effectively as Power Apps via Microsoft's data gateway tools. In summary, Power Apps is not recommended simply because it has already been piloted, it is recommended because it aligns best with the case company's operational requirements, existing digital infrastructure, and long-term scalability goals, while also delivering strong ROI and integration capability.

8. DISCUSSION AND CONCLUSIONS

This chapter summarizes the key findings, presents conclusions and recommendations for the case company along with the limitations of the study and directions for future research.

8.1 Summary of key findings

This study set out to explore how digital tool, particularly low-code development platforms, can improve operations management across a geographically distributed manufacturing organization. While the focus was on low-code platforms, the research also examined the company's current use of tools such as Power BI, SharePoint, Kiwa Impact, and other locally adopted systems supporting production, safety, and daily management practices.

The study investigated what kinds of digital solutions are available for supporting production operations, what type of application system would best suit the company's needs, whether that system should be developed in-house or purchased, and what its successful implementation would require from the organization. The findings confirm that the research questions were effectively addressed through a combination of theoretical analysis and interviews across multiple factory sites. Key insights include:

- **Digital tool usage is highly fragmented across sites**, with a mix of paper-based systems, spreadsheets, and disconnected applications. This fragmentation contributes to inefficiencies, inconsistent follow-up, and poor visibility across the organization.
- **Microsoft Power Apps emerged as the most suitable platform** for building a more integrated and scalable operations management environment. Its alignment with the existing Microsoft ecosystem, accessibility for non-developers, and relatively low marginal cost make it particularly well-suited to the company's needs. This reflects findings by Sahay et al. (2020) and Gurcan and Taentzer (2021), who highlight Power Apps' strong integration capabilities with Microsoft services, its intuitive interface for non-technical users, and its cost-effectiveness as key advantages for organizations seeking scalable, user-friendly low-code solutions.

- **There is strong internal interest in low-code development**, particularly among operational teams who value tools that are intuitive, mobile-accessible, and tailored to real work routines. This aligns with Domański et al. (2023) and Alsaadi et al. (2021), who emphasize that low-code platforms are designed with usability in mind, offering intuitive interfaces, reusable components, and a reduced learning curve that make them especially accessible for non-technical users. This suggests that the expectations expressed internally are consistent with how these platforms are characterized in the literature.
- **Standardization is valued, but only with local flexibility.** Staff expressed a clear desire for shared tools that allow site-specific adjustments in language, process flow, and roles. Ajimati et al. (2025) and Domański et al. (2023) similarly emphasize that low-code platforms such as Power Apps are well-suited to this need, as they support organization-wide templates and structures while still allowing customization at the site level to reflect local requirements.
- **Organizational readiness is a key success factor.** Effective implementation depends on training, leadership support, iterative development, and integration into daily practices, not just on the tools themselves. Ajimati et al. (2025) highlight that without proper support structures, training, and internal alignment, the impact of low-code initiatives can be limited. Similarly, Sanchis et al. (2020) note that iterative, agile development approaches are essential for sustainable digital adoption. This underscores the importance of not only selecting the right platform, but also investing in the organizational capabilities that employees themselves identified as essential for effective implementation.

These findings confirm that low-code platforms like Power Apps can address key challenges identified in the research question, namely tool fragmentation, lack of adaptability, and the need for scalable yet customizable digital solutions.

8.2 Conclusions and recommendations for the case company

Based on the findings, this thesis recommends Microsoft Power Apps as the most suitable platform for enhancing operations management across the case company's sites. This recommendation is independent of the chosen development model. Power Apps provides scalability, strong integration with existing Microsoft tools, accessibility for non-programmers, and supports iterative, user-led development. These qualities, that are also supported by Ajimati et al. (2025) and Sahay et al. (2023), align closely with the company's Smart Operations strategy and the identified needs across diverse sites.

While the case company's UK site has demonstrated the value of in-house low-code development, outsourcing Power Apps development should not be discounted. External vendors specializing in Power Platform development can deliver well-structured, scalable solutions quickly, particularly when internal resources or technical skills are limited. This approach may be especially beneficial for standardizing common tools across sites or accelerating deployment of high-impact apps. Another viable strategy is to hire dedicated Power Platform developers, either as full-time employees or fixed-term specialists, to bridge the gap between in-house ownership and external support. These developers can focus exclusively on low-code solutions, enabling speed and expertise while keeping knowledge internal. Additionally, outsourcing or hiring allows for structured knowledge transfer, where internal teams can later adapt and maintain the developed tools. For the case company, a hybrid model starting with vendor-built or externally staffed solutions and gradually internalizing development may offer the best of both worlds.

To maximize the effectiveness of Power Apps implementation, the following recommendations are proposed:

- Start with scalable pilot projects at digitally mature sites to refine app design and gather feedback. Pilots should be co-developed with end users, tested in real work environments, and used to demonstrate early value. Insights from these pilots can inform broader rollout strategies.
- Establish shared design standards and governance practices to avoid fragmentation while supporting localized flexibility. This includes templates, naming conventions, and modular design principles that promote reuse and maintainability. Apps should follow best practices in low-code development, so they remain adaptable and scalable as needs evolve.
- Prioritize change management and skill development to ensure successful adoption and long-term sustainability. In addition to technical rollout, focus should be placed on leadership support, clear communication, and role-specific onboarding. Formal training programs and informal peer support, tailored to different user groups and technical roles, can build internal capability, reduce support needs, and empower teams to maintain and evolve their own tools.
- Evaluate the use of external vendors or dedicated hires to accelerate development and ensure consistent delivery across geographically diverse sites. This flexible approach can fill capacity gaps and speed up progress, while allowing internal teams to gradually take ownership of solutions over time.

Together, these actions offer a flexible yet focused roadmap for scaling Power Apps across the organization. By aligning technical tools with real operational needs, and by supporting users with the structures, skills, and autonomy to engage with them meaningfully, the company can move toward a more unified, responsive, and digitally mature approach to operations management.

8.3 Research limitations and future research topics

While this thesis provides actionable insights for improving operations management through low-code platforms, several limitations should be acknowledged. This study was limited by its qualitative scope and focus on a single case company. The interviews, while diverse in geography and roles, represent a limited sample and may not capture all perspectives within the company. Additionally, the evaluation of Power Apps is based on a case-specific experience and may not reflect outcomes in different organizational cultures or industries.

The analysis also centered primarily on low-code platforms. While other operational tools were discussed, the theoretical framing may have limited deeper comparison with alternative solutions such as off-the-shelf systems or fully custom-built applications. Furthermore, the platform comparison in Chapter 7.4 was based on documentation and literature, rather than hands-on prototyping. This means that differences in usability, development effort, and long-term maintainability could not be fully assessed.

Additionally, as one researcher conducted both the interviews and thematic analysis, it is important to acknowledge the potential influence of personal perspective on the findings. In line with the interpretive principles outlined by Klein and Myers (1999), reflexivity was maintained throughout the research process to remain aware of how prior knowledge, expectations, and professional background might have shaped data interpretation. During the interviews, efforts were made to ensure shared understanding, especially given the different cultural and linguistic backgrounds of the participants. The main findings were also informally discussed with a company representative to check their clarity and relevance, but this feedback did not lead to any changes in the results or interpretations.

To build on this work, future research could take several directions. Quantitative studies could measure the impact of low-code implementation on operational KPIs, helping to validate the perceived benefits identified in this thesis. Comparative studies developing the same application across multiple low-code platforms could provide deeper insight into practical trade-offs in development speed, scalability, and user experience.

Longitudinal research could explore how user engagement and digital maturity evolve over time. Further investigation into the organizational dynamics of low-code adoption, including governance models and the role of citizen development, would also be valuable.

8.4 Final remarks

This thesis set out to explore how digital tools, particularly low-code platforms, can support more efficient and adaptable operations management in a multi-site manufacturing context. Through a combination of literature review, platform comparison, and qualitative interviews, it has demonstrated that platforms like Microsoft Power Apps offer a viable path toward digital unification, especially when paired with thoughtful implementation and organizational support.

The findings reinforce that successful digital transformation depends not only on selecting the right tools, but on creating the right conditions for those tools to thrive. Usability, integration, local flexibility, and internal capability emerged as critical enablers of adoption. Equally important are governance structures, cross-site collaboration, and leadership that supports experimentation and learning.

While low-code platforms cannot solve every challenge, they represent a powerful toolset for bridging the gap between complex enterprise systems and the practical realities of daily operations. By empowering teams to shape their own digital solutions, whether through internal development, external support, or a combination, the company can move toward a more connected, agile, and data-informed way of working.

Ultimately, the success of this effort will depend not just on the technology itself, but on the company's ability to treat digitalization as an ongoing process of collaboration, adaptation, and growth.

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APPENDIX A: INTERVIEW QUESTIONS

Can you tell me a little about your role and daily work?

Can you tell me how operations management is handled at the plant that you work at?

How do daily management tools appear in your work?

Do you use any specific systems? What is your opinion on them?

How often do you use different systems?

What do you think about the current way of working?

- What works well, and what do you like?
- What doesn't work or causes challenges?

Do you have any suggestions for improving the current workflow?

- In which area would you especially like improvements?
- How could changes save you time or make your work easier?

How much time do current systems take from your daily work?

Is there any task that is particularly time-consuming?

If you could change one thing about the current system, what would it be?

What is something from the current way of working that you would not want to lose?

Have you heard of tools where all daily management tasks could be handled in one place?

What do you think about implementing a new digital tool?

- What benefits do you see for your own work? And in general?
- Do you have any concerns regarding this?

What kind of support or training would be helpful?

What would be the most important benefit of a new system?

What features would be the most important and useful for you in a digital tool?

What could cause resistance to adopting a new system?

What could encourage you or others to learn and start using a new digital system?

Are there any features in other systems that you particularly like?

If a new system were to be introduced, what would be the most important outcome for you?

Is there anything else related to this topic that you would like to bring up?