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Agile Methods And Tools: A Multi-Level Systematic Literature Review And Classification Approach In The Context Of An Iterative Quality- and Factory Planning Process

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Abstract

Product quality is critical to the competitiveness of manufacturing companies facing complex challenges such as shorter product life cycles and competition that has shifted from customers competing for products to manufacturers competing for customers. Therefore, quality management is essential to satisfy today's quality requirements, focusing on error prevention rather than error detection. Since the factory planning process provides the framework for the production factors and restrictions of factory operation, it is necessary to integrate quality management into factory planning at an early stage. The integration must ensure a flexibility to adapt to constant changes, proactively prevent expensive error elimination and ensure high-quality processes. A previously conducted literature review indicated that the existing solutions do not sufficiently integrate quality management into factory planning. Consequently, there is currently no optimal solution approach available that effectively enables targeted and iterative communication between the disciplines of factory planning and quality management. Agile methods and tools can bridge this interface. However, to effectively integrate these methods and tools, they must first be organized into a toolkit that provides methods and tools for different purposes and situations. This paper aims to develop a modular toolkit through a multi-level systematic literature review. This approach categorizes 26 agile methods and tools based on their inputs, outputs, and purposes. The result is a modular toolkit that consists of nine categories and forms the basis for the successful integration of agile methods and tools into the factory planning process according to the Association of German Engineers (VDI) 5200 guideline.

Keywords

Factory planning; reorganization; quality management; agility; quality gates

1. Introduction

The environment in which manufacturing companies operate can be described as turbulent, as the increasing individualization of customer requirements, fluctuating demand, and shorter product lifecycles present manufacturing companies with complex challenges [1,2]. In addition, competition shifted from customers competing for products to manufacturers competing for customers [3]. Moreover, manufacturing companies are facing challenging trends: the evolution from rigid to dynamic markets, megatrends such as the demographic change, a virtual business world, and technological progress [4]. As a direct result of increased customer demands, product quality is becoming essential to the competitiveness of manufacturing companies [1,5]. This, in turn, requires stable and error-free processes, underlining the importance of quality

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management since its primary purpose is to proactively prevent errors [1]. The factory planning process sets the framework for the production factors and restrictions of the factory operations. Since the market requirements are so volatile, the reorganization of factories can be interpreted as a permanent operational task [6]. During the factory planning process, different measures are decided and will be implemented. Often, these measures include topics related to quality management (e.g., implementing a new production process). This means the execution of a factory reorganization is likely to have an impact on the existing quality management system. However, the two disciplines of quality management and factory reorganization are not linked in most companies. The neglect of quality-relevant requirements during a factory planning project can lead to faulty developments in the quality management system. The needed solution approach is split into two parts. First, defining the interfaces between the factory planning process and, secondly, enabling iterative and agile work within these disciplines is necessary. A previous paper by Jahangirkhani et al. [7] already presented an approach for identifying interfaces between the disciplines. This paper focuses on enabling interdisciplinary work through agile tools and methods to support product quality throughout a reorganization.

1.1 Problem statement

As described, the factory planning process lays the foundation for a quality-oriented production system, as the various components and elements of the factory infrastructure directly affect the resulting product quality [1]. A lack of iterative communication between the two disciplines during a reorganization leads to undesirable developments in the quality management system. Consequently, an iterative planning process between the disciplines is needed to align and optimize the planning outcome with the necessary quality management requirements [7]. The problem is that unmet quality requirements are not identified until the ramp-up phase. Subsequent corrections of the planning deficiencies lead to time delays due to the conventional planning process [8]. For small and medium-sized enterprises (SMEs), in particular, such reactive adjustments are almost impossible to manage due to a lack of resources [9]. Such errors during a reorganization can be prevented by integrating quality management more intensively and systematically into the factory planning process. The integration into the planning process enables a flexible adaptation of quality requirements in today's dynamic environment. Therefore, the use of classic, sequential and rigid procedures must be questioned [10]. Instead, a process is needed that allows iterative coordination to deliver and reflect on tangible interim results at an early stage [11]. Agility is designed to respond to the dynamics of today's world. With agility, problem-solving processes or systems can be designed to ensure flexible acceptance and implementation of new or changing requirements [11,12]. This means that teams can be more flexible in meeting the ever-changing demands of the planning process. To do this, people and groups need agility-enabled methods and tools that make it easier to respond appropriately to the speed of change [13].

In order to identify suitable agile methods and tools and to ensure their completeness while providing the necessary transparency, a multi-level systematic literature review in different academic databases is required. An approach is presented that classifies these methods and tools based on their characteristics. Furthermore, a requirement-based evaluation in the context of the VDI 5200 guideline will be performed to assess the suitability of these methods and tools for different factory planning phases.

1.2 Factory Planning according to VDI 5200

The Association of German Engineers (Verein Deutscher Ingenieure – VDI) developed a guideline which describes the different phases of the factory planning process, which is well established in practice and accepted by the scientific community. Current goals of factory planning include economic efficiency, adaptability, resource efficiency, product and production process quality, transparency, sustainability and employee orientation [14,15,6]. Factory planning has a significant practical value, as it determines the long-term structures in manufacturing companies and can therefore decisively influence the profitability of the production process [14]. Consequently, the factory planning process fulfills a crucial role in manufacturing companies, as it sets the fundament for the future [14].

The guideline VDI 5200 distinguishes between the four planning cases of replanning, rescheduling (synonymous: reorganization), deconstruction and revitalization. The planning phases are primarily valid for the planning types of development planning and replanning and are as follows: Setting objectives, establishing the project basis, concept planning, detailed planning, preparation for realization, monitoring realization, ramp-up support and project close-out. The factory planning phases are presented in Figure 1.

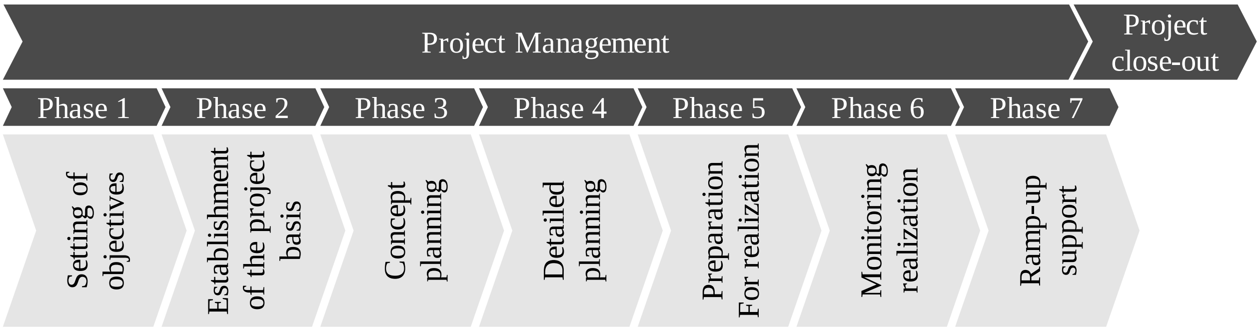

Figure 1: Phase model of the factory planning process according to VDI 5200

Although the guideline breaks down the factory planning procedure in great detail and contains defined goals for each phase, interfaces with other departments and areas are not taken into account. HIRSCH ET AL. highlighted the missing concepts for an integration of quality management into the factory planning process [5]. The diversity of tasks in the factory planning process however requires intensive cooperation between different experts [16].

1.3 Quality Management and Quality Management Systems

The purpose of implementing quality assurance standards and methods is to prevent defects and increase customer satisfaction. Quality management (QM) in an organization aims to deliver products that meet specified requirements. The role of the QM department is to ensure a continuous improvement process in the organization [17].

The DIN EN ISO 9000 series includes international standards and guidelines that describe the basic principles of quality management. Developed by the International Organization for Standardization (ISO), these standards help companies plan, control, and optimize their processes to achieve greater customer satisfaction and operational efficiency. Particularly noteworthy in this context is the DIN EN ISO 9001:2015, which describes the principles and components of an efficient quality management system (QMS). A QMS serves companies as a tool for monitoring and improving the quality of their products and services. It encompasses all organizational activities that contribute to achieving and maintaining an organization's quality objectives. This includes process descriptions, procedural instructions, checklists, training, and quality audits. QMS principles include customer focus, leadership, employee involvement, process focus, continuous improvement, measurement and analysis of processes and products [18]. As per DIN EN ISO 9001:2015, QMS information must be adequately documented and accessible through a network of communication channels to continuously improve business quality. Clear documentation is essential for quality management in companies and serves as the basis for certification of the management system.

DIN EN ISO 9001 certification is designed to improve the quality of a company's work and increase customer confidence. The standard ensures that companies adhere to certain standards and methods for quality assurance. DIN EN ISO 9001 certification signals to customers, suppliers and other business partners that the company has an effective quality management system based on internationally recognized standards.

This is crucial to a company's credibility and reputation [19]. In addition, DIN EN ISO 9001 certification can also satisfy legal requirements in certain industries and protect the company from legal consequences. Overall, certification serves to strengthen a company's competitiveness and improve its reputation in the marketplace [20].

2. Systematic literature review

A multi-level systematic literature review was conducted to assess the current state of research and identify agile methods and tools. This chapter provides a comprehensive overview of the research process and details the structure of the literature review. To assess the extent to which the literature covers the intersection of agile methods and tools and the factory planning process, the literature review first broadly explores agile methods, tools, and classification approaches. The focus is then narrowed to how these concepts relate to factory planning. The chapter concludes with a comprehensive evaluation of the literature. In summary, the systematic literature review identified many suitable agile methods and tools, and highlighted that a classification approach does not yet exist and that these methods and tools have not yet been analyzed in the context of the factory planning process.

2.1 Methods

The following systematic literature review adopts and extends the successful approach of Webster and Watson [21]. This approach ensures that the literature review consists of a structured framework to produce the most valuable results. According to Webster and Watson [21], a high-quality literature review is concept-centric to synthesize the literature better. For this reason, a concept-focused literature research was performed to outline the treatment of agile methods and tools in the literature without excluding research areas other than factory planning initially.

In February 2024, a subsequent research was conducted to verify the relevance of the literature review, initially performed in November 2022. Academic databases were used to provide this systematic literature review with relevant sources. These are SpringerLink[1], ScienceDirect[2], Google Scholar[3], IEEE Xplore[4] and De Gruyter[5]. The databases selected for this literature review were chosen for their reputation of hosting various academic and peer-reviewed sources. Each database specializes in different disciplines and offers an extensive collection of literature (i.e., ScienceDirect offers a wide range of scientific disciplines while Google Scholar additionally covers books). By incorporating these platforms, the goal was to ensure a comprehensive literature review covering various perspectives and high-quality academic content. Congruent Databases were not considered (e.g., Scopus delivers equivalent results to those of Google Scholar). The research was performed in three iterations to determine the degree to which the three research areas factory planning, agility and quality management were combined.

Table 1 lists the predefined search strings that combine keywords with "AND" and "OR" operators to maximize the results of a specific search request. Furthermore, to include English and German literature, the keywords in the search strings were defined in German and English language.

1 https://link.springer.com
2 https://www.sciencedirect.com
3 https://scholar.google.de
4 https://ieeexplore.ieee.org
5 https://www.degruyter.com

Table 1: Search strings

General *(Iteration I)*	**Classification approaches** *(Iteration II)*	**Quality management in the context of factory planning** *(Iteration III)*
("Qualitätsmanagement" **OR** "quality management") **AND** ("Werkzeuge" **OR** "tools" **OR** "Methoden" **OR** "methods") **AND** ("Agilität" **OR** "agility")	("Qualitätsmanagement" **OR** "quality management") **AND** ("Werkzeuge" **OR** "tools" **OR** "Methoden" **OR** "methods") **AND** ("Kategorisierung" **OR** "categorization" **OR** "Klassifikation" **OR** "classification" **OR** "Eigenschaften" **OR** "characteristics") **AND** ("Agilität" or "agility")	("Qualitätsmanagement" **OR** "quality management") **AND** ("Werkzeuge" **OR** "tools" **OR** "Methoden" **OR** "methods") **AND** ("Fabrikplanung" **OR** "factory planning") **AND** ("Agilität" or "agility")

Dividing the research into three iterations has the advantage of gaining a broader overview of the current literature's depth. Inconsistencies, missing approaches, possible research gaps and the current state of the art can be outlined with strict documentation of the process. The first iteration aims to identify and characterize quality management methods and tools in the literature without limiting them to a specific research area. The second iteration focuses on uncovering existing approaches to classify methods and tools. The third iteration is designed to identify literature that puts quality management in the context of factory planning.

A specific time frame of 15 years was set to limit the results, since shorter product and technology lifecycles are forcing manufacturing companies to adapt their factories to changing conditions with increasing frequency [2] and to ensure the relevance of the sources. Furthermore, Google Scholar was used for the backward and forward search[6]. However, the backward search was not limited to a specific period. Search results were manually scanned and included or excluded according to five predefined criteria. Violation of a single criterion results in the exclusion of the literature from further review. The defined criteria are as follows: Selected articles must have an abstract that demonstrates relevance to the research topic (factory planning, quality management, agile methods) (criterion 1). These articles should also include keywords from the search string in the title or abstract (criterion 2), be written in either English or German (criterion 3), and be published between 2007 and 2022 (criterion 4). Finally, each article should examine at least one quality management method or tool (criterion 5). A quality management method or tool refers to established approaches, techniques, or frameworks used to systematically ensure and improve the quality of products, processes, and services within an organization.

The number of search results generated is shown in Table 2. The identified literature was analyzed after the research process, and the criteria were re-evaluated to allow additional exclusions. During this process, a 6th criterion was defined. While the search results were limited by the use of operators and specific keywords in the search string, literature was found that did not demonstrate relevance within the scope of this paper. These publications have been excluded. However, the excluded literature underlines the differentiation of this research area and how agile methods and tools can find application in a wide variety of areas.

6 Performing a backward search means reviewing the references of the articles yielded [21]. Performing a forward search means reviewing sources that have cited the yielded articles [21].

Table 2: Number of search results in the academic databases

	Hits in Iteration I	Hits in Iteration II	Hits in Iteration III	∑ Total hits in Databases
SpringerLink	3.884	3.383	187	7.454
ScienceDirect	1.772	1.556	26	3.354
Google Scholar	230	59	9	298
IEEE Xplore	7	0	0	7
De Gruyter	18	11	1	30
∑ Hits in Iteration	5.911	5.009	223	11.143

Figure 2 illustrates the sequential research process of literature identification, screening, and inclusion. Initially, 34 publications were identified, and an additional 9 were discovered through forward and backward searches. After removing duplicates and excluding 12 publications that did not meet criteria 5 and 6, the remaining 27 publications were included in the literature review.

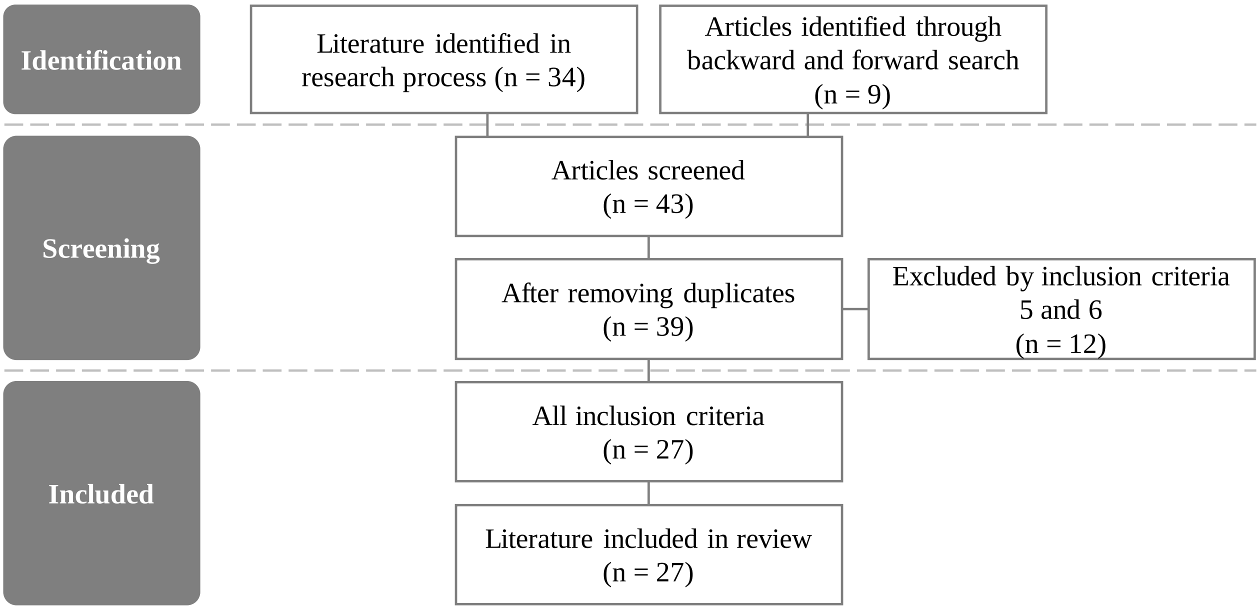

Figure 2: Literature Research Process (adapted from MOHER ET AL. [22])

2.2 Systematic Literature Review - Evaluation

The first iteration yielded 5,911 results (Table 2) across all academic databases, covering diverse research areas such as product development, risk management or controlling. This indicates that agile methods and tools are widely researched. A total of 35 agile methods and tools were identified while 9 of them were excluded on the basis of pre-defined criteria. The remaining 26 methods were analyzed in terms of their *input* and *output parameters*, *implementation effort* and *purpose*. Although the second iteration yielded 5,009 search results (Table 2), none of the literature adequately classified methods and tools based on predefined criteria. Some limited classifications were identified, but they lacked a detailed and transparent classification procedure [3,23]. The third iteration of the systematic literature research yielded a limited number of 223 search results (Table 2). HIRSCH ET AL. stated that there are no developed concepts that allow the consideration of quality management in the factory planning process [5]. However, literature was identified that developed and presented initial approaches to integrate quality management into factory planning

[1,5,4]. Yet, these approaches omit a key aspect – agile methods and tools. To successfully integrate quality management and factory planning, this approach is taking initial steps as agile methods and tools can effectively enable targeted and iterative communication between the disciplines of factory planning and quality management. This research gap and the lack of a detailed classification approach for agile methods and tools, motivates the development of a modular toolkit and the integration of agile methods and tools into the factory planning process.

3. Classification Approach of Agile Methods and Tools in the Context of the Factory Planning Process

HIRSCH ET AL. formulated two key requirements for modern quality management in the context of factory planning [5]. These requirements demand that quality measures should be implemented prior to production [5]. To meet this requirement, agile methods and tools are being investigated in the context of the factory planning process. In addition, the complexity of the entire factory should always be taken into account instead of offering specific solutions [5]. The fact that extensive analyzes have shown that no single method can meet the diverse and complex requirements of factory planning also argues for the development of a modular kit consisting of different methods and tools with different characteristics [4]. For this reason, 26 of the methods found in the research were analyzed, sorted and categorized. The categorization was made by four characteristics *input*, *output*, *implementation* and *purpose*.

Input refers to the necessary information required for each method or tool to function. While histograms require previously recorded data to be created, the input for retrospective meetings is provided by the participants based on their experience. O*utput* refers to what is available after successful execution. Brainstorming, for example, provides solutions and action plans. The characteristic *implementation* indicates the required time and effort for participants. The required time was classified as low to high. All methods and tools that can be performed within a few hours to a day (e.g., stand-up meetings lasting 15 minutes or the brainstorming method requiring less than an hour) were classified as low. On the other hand, methods and tools that take a few days to complete (e.g., personas) were rated medium, while methods and tools that take weeks to months to complete, such as the design thinking method, were rated high. The effort required by employees to perform a method or tool is also rated as low to high. On the one hand, some methods and tools require little effort, such as defect collection lists that can be easily created based on empirical data, while on the other hand, some methods and tools require the commitment of participants and are therefore rated as high effort. In addition, the specific *purposes* of the methods and tools were recorded to reveal further similarities and differences.

Table 3, which is alphabetical, was created for the classification approach and includes all characteristics. In addition to the identified characteristics (i.e., *input*, *output*, etc.) it was possible to derive categories into which the methods could be divided. The derived categories were the following:

- Coordination and communication of the structure
- Creative solution approaches
- Error prevention
- Frameworks
- Goal setting and action plans
- Recording and communication of the current state
- Reflection
- Risk analysis and visualization
- Target-performance comparison

Table 3: Overview of the Classification Approach

Tool [Literature]	**Input**	**Output**	**Implementation**	**Purpose**	**Category**
Appreciative inquiry (AI) [25,27,26,24]	Participants provide ideas based on past experiences on a central focus. An experienced large group moderator is required.	Action plan, Solution approach	Time requirement: low (0.5 – 1 day) Effort for participants: high (participation is required for input)	Can be performed with large groups (up to 750 participants) to transform ideas into action plans and find solution approaches while reflecting the past.	Reflection / Goal setting and action plans
Bowtie method [31,30,28,29]	Participants provide input based on creative ideas while data is not essential	Action plan, Solution approach	Time requirement: low - high (depending on the objective) Effort for participants: low - high (depending on the objective)	Discover solutions to problems with low complexity on a given topic	Creative solution approaches
Brainstorming [31,30,28,29]	Participants provide input based on creative ideas, data is not essential	Action plan, Solution approach	Time requirement: low (< 1 hour) Effort for participants: high (participation is required for input)	Discover solutions to problems with low complexity on a given topic with a heterogenic group of five to seven participants	Creative solution approaches
Cause-event diagram, Ishikawa diagram [31,32,3,28,33,29]	Experts' opinions	Diagram with organized factors influencing a variable / triggering one effect	Time requirement: low Effort for participants: low	Systematic and complete identification of causes for a problem, the analyzis and the structuring of processes by visualizing more complex structures	Risk analyzis and visualization
Checklists [28,29]	Experts' opinions	Collection of requirements / check for completeness	Time requirement: low (decreases over time) Effort for participants: medium	Identification of requirements and inspection for completeness	Target-performance comparison
Delphi Method [29]	Experts' opinions	Risk identification and analyzis	Time requirement: high (months) Effort for participants: high	Multi-stage survey process that captures expert opinions and refines them by reevaluating anonymized (interim) results	Error prevention / Risk analyzis and visualization
Design thinking [34,24,23]	Participants provide input	Action plan, innovative solution approaches	Time requirement: high (weeks - months) Effort for participants: high	Development of innovative products and unique solutions while constantly thinking and acting from the users' perspective	Frameworks
Error collection list [36,35,32,3,33,37]	Empirical data	Presentation of data; Derived action plans	Time requirement: low Effort for participants: low	Accurately record and present data (e.g., faults) organized by type and number	Accurately record and present data organized by type and number

Fault tree analyzis (FTA) [35,3,28,29,37]	Description of the system	Visualization of risks	Time requirement: medium (decreases over time) Effort for participants: low-medium	Assess and optimize systems or products concerning their safety and reliability	Error prevention / Risk analysis and visualization
Failure mode and effect analysis (FMEA) [31,32,30,28,33,29,37]	Participants provide input	Error prevention options	Time requirement: high Effort for participants: high	Systematic and complete identification of possible problems, risks and consequences before they occur	Error prevention
Histogram [35,32,3,38,33,29]	Recorded data	Visualization and analysis of recorded data	Time requirement: low Effort for participants: low	Clear visualization and analysis of recorded data	Recording and communication of the current state
Interview [38,29]	Experts' opinions	Collection of conflicting or overlapping perspectives on a specific topic	Time requirement: low-high (depends on the scope) Effort for participants: low-high (depends on the scope)	Impulses for further thought patterns	Recording and communication of the current state
Kanban boards [34,39,40,26,24,23]	Tasks	Visualization and limitation of workflow	Time requirement: low Effort for participants: low	Planning, limiting, visualizing and organizing tasks and resources.	Target-performance comparison / Coordination and communication of the structure
Meta-communication [26]	Perceptions of the participants providing input based on creative ideas	Reflection and evaluation	Time requirement: low Effort for participants: high (participation is required for input)	Reflection to evaluate, optimize and develop the team	Reflection
Method 6-3-5 [28,29]	Participants provide input based on creative ideas	Action plan, Solution approach	Time requirement: low Effort for participants: high (participation is required for input)	Find unique solution approaches for problems with a compact group of six	Creative solution approaches
Mind-mapping [29]	Participants provide input based on creative ideas	Visual collection of ideas	Time requirement: low Effort for participants: low	Gathering ideas through keywords.	Creative solution approaches
Pareto chart [31,32,30]	Recorded data	Visualization and analysis of recorded data	Time requirement: low Effort for participants: low	Illustrate the leading causes of problems ordered by the importance of their effects	Risk analysis and visualization
Personas [41,23]	Participants provide input	Analysis of requirements; action plans	Time requirement: low-medium Effort for participants: low-medium	Uncover needs and analyze requirements	Goal setting and action plans

Prototyping [23,37]	Participants provide input	Concretization of an idea, further starting points for unique solutions	Time requirement: medium-high (depends on the prototype) Effort for participants: medium-high (depends on the prototype)	Accurately identify complex relationships in an early stage	Error prevention
Retrospectives [26,24,42,23]	Participants provide input based on past experiences	Action plan, Solution approach	Time requirement: low-medium (minutes – days) Effort for participants: high (participation is required for input)	Backward analysis of what has happened so far; Identifying reporting and solving the most critical issues with a compact group with 7-9 participants	Goal setting and action plans / Reflection
Reverse thinking [28,29]	Participants provide input based on creative ideas	Unique ideas and solutions to problems, identified risks	Time requirement: low Effort for participants: high (participation is required for input)	Reflection to evaluate, optimize and develop the team	Creative solution approaches / Error prevention
Risk identification matrix [29]	Risk causes and effects	Scores for different cause and effect combinations	Time requirement: low Effort for participants: low	Evaluate risks with low time and effort	Error prevention
Standup meeting [34,40,26,23]	Participants provide input based on past experiences	Better team coordination and communication	Time requirement: low (15 minutes) Effort for participants: high (participation is required for input)	Coordinate activities and goals and communicate them transparently to each member	Coordination and communicati on of the structure
Team reflection [26,37]	Participants provide input based on past experiences	Better team coordination and communication	Time requirement: low (5 - 10 minutes) Effort for participants: high (participation is required for input)	Developing new and questioning existing processes	Reflection
Timeboxing [34,26,23]	Available time	Timeboxes	Time requirement: low Effort for participants: low	Time management	Coordination and communicati on of the structure
World-Café [29]	Participants provide input	Visual collection of discussed ideas	Time requirement: medium Effort for participants: medium	Question discussing in changing groups	Coordination and communicati on of the structure

The resulting overview can be used as a modular toolkit of methods. Based on this, users can now search for the appropriate method for their use case. The categories can be used as a superordinate group. The methods within a category can then be differentiated according to the desired output, the required time or the effort involved. In this way, a suitable method can be selected for many use cases. Some of the methods are similar and can then be used, for example, to match existing knowledge.

The tool kit, consisting of various specific categories, is intended to ensure flexibility through its modular character by providing a broad spectrum of suitable methods and tools. A strict limitation of categories to certain phases of the factory planning process according to VDI 5200 contradicts the modular character. This will be demonstrated by the example of the category "Creative Solution approaches":

Creative solution approaches are generally beneficial whenever conventional solution approaches do not lead to a satisfactory outcome. For this reason, it is valuable to have access to methods and tools that provide unique and creative solution approaches. Since these methods and tools do not require data, they can be employed at an early planning phase. Especially in the establishment of the project basis, it is not a creative but a systematic approach divided into the procurement of information and the evaluation of information [15]. While the primary focus of this phase is on identifying weaknesses and potentials [6] brainstorming or reverse thinking can help to manage the problem of determining what information and data is needed to identify possible weaknesses and potentials. This category would not directly contribute to the collection and analysis of data but would be used in a supportive way by generating ideas about what data should be collected. Moreover, even in phases where many factors have already been determined and there is little room for change and creativity, the methods and tools in this category can be used to solve problems in the planning team. Consequently, there is no limitation of this category to any phase from the factory planning process.

The detailed and critical evaluation of the individual categories in the specific context of the factory planning process revealed that every category can find application in any planning phase. It must be stressed that the decision to not make clear limitations, but to allow the access to all categories at each phase of planning provides more operational flexibility and adaptability to diverse initial situations and conditions. In addition, open access enables the most efficient use of all resources since subtasks and subgoals can also be achieved through different methods. Furthermore, modularity promotes innovative approaches since the procedure and the sequence of methods and tools are not predetermined but support individual and innovative approaches through flexibility.

In addition to the 26 included methods, there were also nine methods, that were excluded from further investigation for one of the following reasons: The method was not suitable for the application context (a) or according to the literature there is another method that should be used instead (b). The excluded methods are presented in Table 4.

Table 4: Excluded methods

Method / Tool	Reason for exclusion		Literature
Chief election	(a)	Not suitable for project teams, deployment at management level	[26]
Delegation board	(a)	Not suitable for project teams, deployment at management level	[26]
Dragon dreaming	(a)	Suitable for project teams trying to improve team spirit	[29,37]
Group fields	(a)	Not suitable for project teams, deployment for team development	[26]
Lean startup	(b)	Customer centric: Design thinking is more appropriate	[23]
Pairing	(a)	Not suitable for project teams, deployment for groups of two	[40,26]
Quality Function Deployment (QFD)	(b)	Literature states that Personas are superior to this method.	[32,3,30,33]
Scrum	(b)	Customer centric: Design thinking is more appropriate	[23]
SWOT-analysis	(a)	Suitable for corporate strategy.	[33]

4. Conclusion

The objective of this paper was to investigate agile methods and tools and their applicability in the context of the factory planning process according to the VDI 5200. The need for an early integration of quality management for manufacturing companies results from the fact that product quality is becoming essential for the competitiveness of manufacturing companies as customer requirements increase and become more individualized. Since the task of factory reorganization is becoming a permanent one, it is crucial to integrate quality management into the factory planning process to avoid errors from being repeated in other areas and proactively prevent expensive error elimination measures to ensure high-quality processes in factories that are essential for high-quality products.

The systematic literature review provided evidence for the research gap in the agile tools and methods and factory planning literature since no approach was identified that aimed for a classification of agile methods and tools and their iterative integration into the factory planning process according to the VDI 5200. From the result of the literature research a toolkit including the 26 identified quality management methods and tools was developed by analyzing their characteristics. The predefined characteristics included the input, output, implementation effort as well as the purpose. This approach allowed a transparent classification of the tools and methods into nine categories attempting to address the identified research gap. The results indicate that the categories with agile methods and tools cannot be limited to specific phases of the factory planning process according to the VDI 5200, as this would compromise the modular character of the tool kit. Maintaining modularity by providing access to all categories in all planning phases ensures the general applicability of the developed model, independent of the specific planning case or conditions.

The developed toolkit (Table 3) represents a summary of agile tools and methods that can be used during an iterative factory and quality planning process. As mentioned, derived categories can support the targeted application of the identified tools and methods. In order to exploit the full potential of it, it is necessary to connect the results of this paper with the one where the interfaces between the disciplines are identified [7]. Combined they provide the base for developing agile quality gates in factory planning. These quality gates include predefined checklists tailored to specific planning scenarios. A thorough completion of checklist objectives is critical to quality gate approval. Integrating quality gates into each phase increases transparency, allowing the factory planning and quality management team to understand the milestones required for progress collectively.

To conclude the paper, it is essential to highlight the potential areas for further development of the results presented. One such opportunity is the development of a factory and quality planning procedure that enables the early integration of quality management into the factory planning process with the VDI guideline 5200. The process model strives for a standardized and quality-assuring procedure for the reorganization of factories in order to take quality requirements into account right from the start of factory planning. The result is the early and long-term minimization of potential undesirable developments in quality management during factory planning and reorganized factory operations. The further development of the results is the focus of ongoing research activities, which concentrate on making the identified agile toolkit more applicable in practice. This aspired framework facilitates using various agile tools and methods to achieve different objectives within each phase, ultimately ensuring a structured and systematic process.

5. Acknowledgments

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