

Use Cases of Generative AI In Factory Planning: Potential and Challenges

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Abstract: Global competition is forcing companies to cut costs. The design process is time-consuming, as documents often need to be analysed. The use of artificial intelligence (AI) promises to reduce this time. Many companies rely on the use of existing AI solutions. ChatGPT is an application that can support the design process and is easy for non-experts to use. The use of chatbots is suited to data-intensive areas such as factory planning, but the potential in factory planning is still unclear. This paper analyses the use of ChatGPT in factory planning and describes and evaluates different use cases.

Keywords: Artificial Intelligence (AI), Case Study, Production Design, ChatGPT, Factory Planning

1 Introduction

The megatrends of globalisation, sustainability and digitalisation are challenging companies to adapt to new ways of working and strategies to secure their long-term competitiveness (Kharatyan et al. 2021). The manufacturing industry is undergoing a fundamental transformation as digital innovations drive fundamental changes in the production and product development process (Ködding und Dumitrescu 2021). One driver of change is the use of artificial intelligence (AI), which offers far-reaching support potential, particularly for knowledge-intensive activities. With the help of AI, relevant information can be extracted from unstructured data to generalise it in the form of knowledge and thus support business processes (Ahlborn et al. 2019). The use of AI is particularly promising in product creation due to the increase in knowledge-intensive activities and the rapid acceleration of innovation cycles (Dumitrescu et al. 2021). While AI applications are already being used in the phases of strategic product planning, product development and service development, the potential in production system development, particularly in factory planning, is still largely unknown. The high availability and generation of data (e.g., factory layouts and material flows) within a factory planning project promise good conditions for the applicability of AI (Bracht et al. 2018). There are two basic approaches to the use of AI in factory planning. On the one hand, a "comprehensive AI" can be developed to completely replace a factory planner. On the other hand, AI solutions can be used to support or replace individual activities of a factory planner or sub-processes of factory planning (Ahlborn et al. 2019). The advantage of using Generative Artificial Intelligence (GenAI) in factory planning is that it can support such text-based activities as target planning and the creation of a specification sheet. GenAI can revolutionise factory planning by creating efficient layouts, predicting demand, and optimising workflows. It enables real-time scenario analysis and resource allocation, leading to increased productivity and reduced costs. In practice, however, many companies face the challenge of seeing the economic benefits of using GenAI, but not having the resources to realise them (Dukino et al. 2019). This paper therefore takes the approach that companies can use existing low-threshold GenAI solutions to achieve low-threshold economic value using GenAI.

Among AI technologies, the subfield of GenAI is proving to be a promising approach that has become increasingly important in recent years. This is a technology that can generate and output new content such as text, images, audio, or other formats based on specifications and information (Bendel 2023a). The generation of output can significantly support activities in early phases, which can increase the efficiency of development projects by 10 to 15 % (Dumitrescu et al. 2020). The market research company Gartner takes a similar view and places GenAI technology at the top of the Gartner Hype Cycle in 2023 (Lori et al. 2023). GenAI is already being used intensively in product development, for example to generate many product variants in the shortest possible time during the design phase and suggest them to developers. In this way, completely new and previously unrealisable product designs can be generated with optimal utilisation of the materials and the necessary manufacturing processes and used as input for detailed development tasks (Streibich et al. 2020). With the release of the ChatGPT application in 2023, a GenAI tool will be made available for a wide range of use cases for the first time, which will significantly increase the acceptance and understanding of the use of GenAI in various industries and sectors (Deng et al. 2022). This application enables employees of industrial companies to support and optimise their business processes and activities with GenAI. This can provide great potential, particularly in factory planning.

The aim of this paper is to identify the application potential of ChatGPT in factory planning (In this paper, "potential" is understood to mean the reduction of planning errors and the acceleration of processes.). Specifically, the aim is to investigate in which phases of the factory planning process users can be significantly supported by the GenAI chatbot. In

addition, the potential found is not only identified, but also evaluated in terms of the degree of automation of the process step. To this end, an AI application catalogue was developed as part of this article, which structures the possible uses of ChatGPT along the factory planning process and its capabilities. The paper is structured as followed: As part of a problem analysis in Chapter 2, the circumstances, and challenges of GenAI and factory planning are highlighted. Then, Chapter 3 provides an overview of the current state of the art and related research on this topic. Chapter 4 explains the underlying research method used in this paper. The results of this article are presented in Chapter 5 in the form of a structured use case catalogue. Finally, the results are discussed in chapter 6.

2 Theoretical background

This chapter covers the two main components of this paper: AI and factory planning. First, AI is defined and ChatGPT is placed within the AI process, and then ChatGPT is explained in more detail (chapter 2.1). This is followed by a discussion of factory planning and its phases (chapter 2.2).

2.1 Generative AI

In this paper, the term AI refers to the definition of AI systems of the International Organization for Standardization (ISO). According to the ISO, AI systems are able to generate various outputs based on objectives that are defined by a human (ISO/IEC 22989:2022). Therefore, AI systems can be versatile, which is why they are further classified. Figure 1 shows the AI categories that are used in this paper. In this chapter first the AI-related terms are shortly defined. Secondly, it is explained how ChatGPT can be classified according to the terms.

The term **Machine Learning** (ML) is a generic term which describes that the parameters of the AI system are optimized computationally by reflecting the data or experience of the AI system automatically (ISO/IEC 22989:2022). AI systems described with the term **GenAI** can generate different kinds of results such as images, video, audio or text in a seemingly creative way. For this purpose, GenAI systems use ML algorithms (Bendel 2023a). GenAI systems that can generate texts in a natural language are further classified as **Large Language Models** (LLM). LLM are trained on vast quantities of textual data, enabling them to accomplish various language-related tasks with high precision (Kasneji et al. 2023). Finally, **Conversational Agents** are defined as computational dialogue systems capable of understanding and generating human speech. When the input and output is in text form, the conversational agent is further classified as a chatbot (Bendel 2023b). **ChatGPT** can generate vast amounts of texts and interact in a natural human way to human input. Therefore, according to the presented AI-related categories, ChatGPT can be classified as a chatbot or conversational agent, LLM and GenAI that was trained using ML algorithms (van Dis et al. 2023).

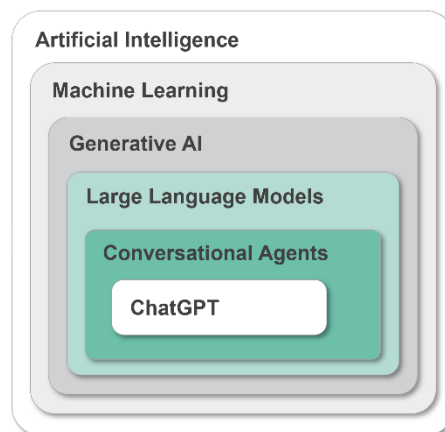


Figure 1. Classification of Generative AI and ChatGPT in AI models

According to OpenAI, the database used to train ChatGPT is made up of three areas: The first area consists of information that is publicly available on the Internet. Secondly, data licensed by OpenAI was used. Thirdly, ChatGPT was trained with information entered by users and human trainers (OpenAI, Inc. 2023a). The training was carried out using the Reinforcement Learning with Human Feedback method, in which the AI receives feedback for its responses from human trainers in order to achieve the desired behaviour of the AI (OpenAI, Inc. 2023b). The possibilities of ChatGPT have been expanded several times since its first release. For example, since September 2023, ChatGPT has included the option of making entries in the form of spoken language or images. Furthermore, since October 2023, the AI DALL-E 3 has been integrated into ChatGPT, which can be used to generate and output images (OpenAI, Inc. 2024a).

2.2 Factory Planning

Factory planning is becoming increasingly important in industrial companies due to rapidly changing production requirements and market conditions (Grundig 2021). Factory planning describes a systematic, goal-orientated and sequential process for planning a factory from the definition of objectives to commissioning, which is carried out using methods and tools (VDI-Richtlinie VDI5200-1). According to 4-cycle model of product development from Gausemeier et al., it is clearly assigned to production system development in addition to the phases of strategic product planning, product and service development (Gausemeier et al. 2019). Although the factory planning process has several interfaces with product development, end-to-end development has often not been achieved due to various challenges. (Disselkamp et al. 2023; Disselkamp et al. 2024) The planning process requires the expertise of various technical experts from different disciplines (Pawellek 2014). According to Grundig (Grundig 2021), it is divided into the six phases: **target planning**, **preliminary planning**, **rough planning**, **detailed planning**, **implementation planning** and **realisation**. These steps differ in particular in their level of planning detail, which increases as the process progresses (Burggräf und Schuh 2021). As can be seen in Figure 2, the phases in factory planning are subject to specific planning tasks, which are evaluated in this paper regarding their potential in the context of ChatGPT. **Target planning** forms the first planning phase and includes the development of targets and planning principles for the initial preparation of the planning project. In the **preliminary planning** phase, initial results are developed by specifying the content of key work areas. This includes the analysis of the production potential, the derivation of the production programme, the clarification of a suitable location, the development of the logistics specifications and the initial assessment of the necessary requirements. The second main phase comprises **rough planning**, which represents the innovative focus of the factory planning process. In addition to the functional definition and dimensioning, the development of an ideal layout and several alternative real layouts take centre stage. While functional units (areas, systems, machines) are arranged in the factory within the ideal planning without taking restrictions into account, the real layout must subsequently be adapted to practical conditions (e.g. existing factory space). In the **detailed planning** phase, the preferred layout variant is further detailed until it is ready for implementation, which includes the fine arrangement and the design of a workstation. The fifth phase is **implementation planning**, which includes all preparatory measures and decisions required for the successful organisational, technical, and structural implementation of the planned project. In the final phase, the **realisation** phase, the structures, or facilities are built and commissioned. To this end, the movements foreseen in the implementation planning are put into practice (Grundig 2021).

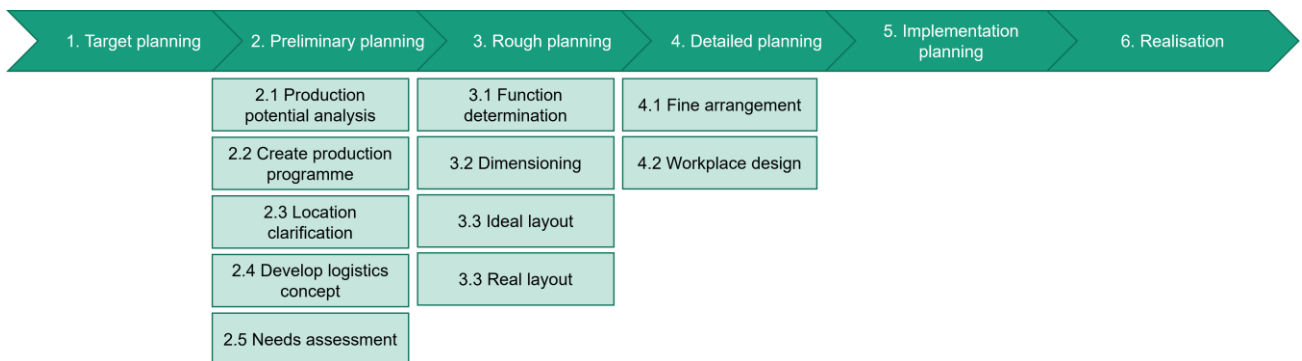


Figure 2. Factory planning process according to Grundig (Grundig 2021)

Current approaches focus, for example, on the development of a digital factory twin (Cieply et al. 2024) or the challenges in the development of simulation models (Kattenstroth et al. 2024). Existing factory planning methods often involve labour-intensive and time-consuming processes that require significant human expertise and manual input at every stage. These traditional approaches can struggle with the following things:

- **Complexity and integration:** Traditional factory planning involves multiple phases, each requiring detailed input and coordination from different experts. This can lead to fragmented processes and communication gaps. Generative AI can streamline these processes by providing integrated and cohesive planning tools that enhance collaboration and ensure that all relevant factors are considered simultaneously.
- **Flexibility and adaptability:** Rapid changes in market conditions and production requirements demand flexible and adaptive planning solutions. Traditional methods may lack the agility to quickly adjust plans based on new data or changing circumstances. Generative AI provides dynamic and real-time scenario analysis, allowing planners to quickly adjust layouts and workflows to meet evolving needs.
- **Optimization and efficiency:** Traditional methods may not fully optimize layout designs and resource allocations, resulting in inefficiencies and increased costs. Generative AI algorithms can explore a vast number of design permutations and identify optimal configurations that maximize space utilization, minimize material handling costs, and improve overall production efficiency.

- **Decision support:** Factory planning requires making informed decisions based on complex data and numerous variables. Human planners can struggle with data overload and the intricacies of balancing multiple objectives. Generative AI can provide advanced decision support by processing and analyzing complex data sets, providing actionable insights, and recommending data-driven decisions.

By addressing these shortcomings, generative AI has the potential to revolutionise factory planning, making it more efficient, adaptive and data-driven. This integration of advanced AI tools can lead to more optimised, flexible, and resilient manufacturing operations, ultimately improving the competitiveness and productivity of industrial companies. This paper will primarily focus on the decision support of factory planners and include several other parts partially.

3 State of the art

In the field of operating manufacturing facilities and the associated processes, the use of a wide range of AI tools has been investigated to date with varying degrees of success (Arinez et al. 2020). Additionally, because of the comparably short history of AI, the current research is active and promising (Wang 2019). However, when it comes to factory design, only a few academic publications have addressed the use of AI. Moreover, because factory design is such a broad and diverse discipline, several published studies do not cover the entire factory design process, but rather focus on a subset. For example, a bibliometric analysis by Burggräf et al. examines the application of machine learning to solving plant layout problems, which is a sub-discipline of factory planning (Burggraf et al. 2021).

The challenge that there are currently only a few publications on the topic of AI in factory planning as an overarching process also applies to the use of ChatGPT. Due to the novelty of ChatGPT, there are only a few scientific papers that have investigated the behaviour of ChatGPT. However, the existing publications indicate that ChatGPT's suitability varies across different tasks. For tasks where ChatGPT is asked to generate new ideas in a creative way, e.g., a completely new product design concept, it seems to deliver beneficial and versatile results. However, when detailed and in-depth technical knowledge is required from ChatGPT, the AI seems to deliver less satisfactory results. One possible reason for this is the generality of the database with which the AI was trained. When asked for in-depth technical knowledge, ChatGPT may hallucinate rather than providing correct knowledge, i.e. the output does not correspond to the truth (van Dis et al. 2023; Wang et al. 2023b). The user's prompts have a decisive influence on hallucinating, e.g. hallucinations of ChatGPT occur more frequently with prompts that are written in a commanding tone than with prompts that are formulated in an interrogative manner (Wang et al. 2023b). Because the form of the prompts also has a major influence on the output of ChatGPT apart from the hallucinations, the manufacturer OpenAI Inc. itself provides instructions for formulating the prompts for the users (OpenAI, Inc. 2024b). Since the level of detail of the input also influences the output, users should have a corresponding basic knowledge in order to write appropriate prompts (Wang et al. 2023b).

Wang et al. present the concept of the Industrial GPT for use in solving various scenario tasks in factory operations. The model is pre-trained with industrial data sets, refined with specific business scenarios, and trained with domain knowledge using reinforcement learning. In order to make the Industrial-GPT more usable for the manufacturing industry, the "Model as a Service" is introduced, which enables a more efficient and flexible service delivery (Wang et al. 2023a).

The research gap addressed in this paper is that ChatGPT has not yet been investigated and applied to factory planning. Existing solutions do not yet consider the different potentials of GenAI in factory planning (see chapter 2.2). This paper therefore analyses where the use of ChatGPT makes sense.

4 Research Design

The research design for this examination is subdivided into an *overarching* and a *specific research methodology*. As the *overarching research methodology* the Design Research Methodology (DRM) published by Blessing and Chakrabarti is used (Blessing und Chakrabarti 2009). According to the DRM the research is divided into four phases (1. research clarification, 2. descriptive study I, 3. prescriptive study, 4. descriptive study II). The DRM distinguishes seven different types of design projects, which differ in the characteristics of the four phases. For this approach, type 2 of the design research projects was selected. Thus, this thesis is based on the first two phases and deals with the third phase. The chapters of this paper are based on the framework. The research question is the focus of this chapter. Chapters 2 and 3 contain a summary of the conducted descriptive study I. Finally, our findings from the initial prescriptive study are presented in chapter 5. This study examines the following research question:

At what stages of factory planning is it suitable to use GenAI to perform tasks semi-automatically or automatically?

The action design research method by Sein et al. was selected as the *specific research methodology* for the initial prescriptive study of the DRM (Sein et al. 2011). The method consists of four stages: 1. Problem Formulation, 2. Building, Intervention and Evaluation, 3. Reflection and Learning and 4. Formalization of Learning. In the first stage, the problem

to be addressed within the research is formulated, leading to the development of the research question. In this paper, the research question was formulated based on knowledge from an industry practice project as well as previous research. In the second stage, a solution design is developed, implemented, and evaluated. This procedure is repeated iteratively until the result is satisfactory. Concurrently, the third stage is conducted, which includes reflection on the findings and derivation of results. Finally, the results are formalized and documented. The specific procedure for the phases already described in this paper is described below:

1. **Problem Formulation:** In this paper, the research question (“At what stages of factory planning is it suitable to use GenAI to perform tasks semi-automatically or automatically?”) was formulated based on knowledge from an industry practice project as well as previous research.
2. **Building, Intervention and Evaluation:** For this study, the different phases of factory planning were distinguished. Factory planning is thus divided into six phases. This article concentrates on the first five planning phases, as the execution is characterised by physical elements and is company specific. For each phase the inputs and outputs were identified. Specific artefacts (e.g., documents or models) resulting from each planning phase were then defined. To reproduce the artefacts and evaluate ChatGPT, the chatbot was asked to plan a battery factory with the help of prompts. ChatGPT's responses were compared with real-world planning results, analysed and, if necessary, the prompt was adjusted, and a new request formulated. As part of this work, ChatGPT-4 was used for the period from November 2023 to February 2024.
3. **Reflection and Learning:** The prompts and results of ChatGPT were reflected upon and discussed with industry experts. An example of this is the generation of factory layouts, because although some graphically appealing images were generated, they were not based on the input. As a result, the process was adapted for ChatGPT. When creating the ChatGPT layout, the initial focus was on creating images. As a result of discussion with the experts, the layout was no longer created as an image, but in the form of a formalised language such as ASCII code.
4. **Formalization of Learning:** The results of this study have been summarised in the form of a Use Case Matrix, which is formalised in this document. This enables companies to select a use case directly in the ChatGPT factory design.

5 Findings

Many companies are faced with the challenge of how to use AI profitably in business practice without developing their own AI solutions. Small and medium-sized enterprises prefer to use existing AI programmes that promise "direct" benefits. As planning processes are particularly characterised by "searching and summarising", the use of AI programmes such as ChatGPT is particularly suitable here. This chapter summarises the results of the study on the use of ChatGPT in factory planning. The study compared responses from ChatGPT-4 with real planning data. The research design is described in Chapter 4. An exemplary request to ChatGPT looked like this:

Hi, I want to plan a factory that includes a production for battery cells for research purposes of the Fraunhofer society. For that I need to search for the location for the factory. Can you help me with that? The factory should be located in Germany. [...] If you need some more information from me, please ask me. You are the expert.

After several follow-up questions, including "Can you give me more details concerning the location? Can you tell me a specific location, on which i can build my factory?", we received the following response:

Based on the methodology outlined in the document you provided and considering the factors for a Fraunhofer Society's battery cell production factory, three specific locations in Germany stand out as potential sites:

Heidelberg Technology Park: This park has been a center for innovation for over 35 years, bringing together researchers, startups, and large-scale institutions to collaborate in a dynamic ecosystem. [...] Its infrastructure and services support business development and provide access to a national and international network, which could be beneficial for the Fraunhofer Society's research and development in battery technology.






Berlin Adlershof - Science City: Known as Germany's leading science and technology park, Adlershof is home to more than 1,270 businesses, including non-university research institutes and the natural sciences campus of Humboldt-Universität zu Berlin. [...]

The use of ChatGPT is analysed along the five factory planning phases that are the focus of this paper: target planning (chapter 5.1), preliminary planning (chapter 5.2), rough planning (chapter 5.3), detailed planning (chapter 5.4) and implementation planning (chapter 5.5). Some use cases are described in detail in the chapters on the phases of factory

planning. The illustration of all analysed use cases is shown for target planning and preliminary planning in Table 1 and for rough planning and detailed planning in Table 2.

The Use Case Matrix distinguishes five **capability levels** in a horizontal direction (x-axis): **inform, analyse, optimise, simulate, visualise**. The capability levels were identified through a literature review analysing the activities of a factory planner. **Informing** is an essential part of factory planning, as targeted and comprehensive information forms the basis for further decisions to create an understanding of the current situation (Burggräf und Schuh 2021). **Analyse** is the process of evaluating the collected data to identify bottlenecks, inefficiencies and opportunities for improvement within the factory processes (Grundig 2021). The **“Optimise”** capability describes how, based on the analysis, actions and strategies are developed to improve and optimise processes, e.g. by redesigning layouts or improving workflows (Pawellek 2014). In the **“Simulate”** capability, the changes and optimisations are tested using simulations to assess the impact on production without disrupting real operations (Wiendahl et al. 2014). Finally, the planned factory layouts and processes are **visualised** to help understand and communicate the changes (Grundig 2021).

Table 1. Use cases in target and preliminary planning for the use of ChatGPT

| Process | | Inform | Analyse | Optimise | Simulate | Visualise |
|------------------|-------------------------------|---|---|--|--|---|
| Planning Tasks | |  |  |  |  |  |
| Factory planning | Target planning | Describe basic problems and objectives of factory planning and set cost frameworks | Name the necessary functional areas of the factory | - No application - | - No application - | - No application - |
| | Production potential analysis | Name the procedure and objectives of the production potential analysis | Compile corresponding product, process and location data | - No application - | Develop future scenarios such as growth in demand or disruptive technological developments and assess their impact | - No application - |
| | Create production programme | Provide rough information on product type, range, quantities, capacity requirements and price | Elaborate important aspects of historical production data, such as scalability of production, major cost items, logistics concept | Identify measures to prevent the analysed aspects, e.g. modularity of the factory, training of the workforce | - No application - | - No application - |
| | Location clarification | Aspects that need to be considered in site planning such as infrastructure, labour, environment and initial proposals | Description of several possible locations (industrial or commercial areas) based on an internet search | Selection of a suitable industrial park, considering rough specifications such as transport links, space requirements, environment | Estimate future effects of the choice of location (10-20 years), e.g. expansion areas, cost development, transport links | - No application - |
| | Develop logistics concept | Name the basics of a logistics concept | Developing approaches for transport system requirements | Name specific types of transport equipment (e.g. forklift trucks) that fulfill requirements regarding maximum load and height | - No application - | - No application - |
| | Needs assessment | State TGA requirements | Estimate space requirements based on the targeted production volume | Identify measures to realise factories on too little, limited land area | - No application - | - No application - |

Legend: Low automation Conditional automation Full automation

The **planning processes** and their tasks are listed on the vertical axis (e.g., location clarification as a preliminary planning task) (y-axis). The matrix entries result from the relationship between capability levels (x-axis) and planning activities (y-axis). These matrix entries describe use cases for the application of ChatGPT. For example, ChatGPT can be used in the planning activity of *location clarification* to *inform* by listing initial location suggestions or to highlight criteria that will be considered when selecting a location. There are also some AI capabilities levels that are not used in the planning phase. These are marked “- No application -”.

These use cases are evaluated using a traffic light scale. The traffic light scale used is based on the levels of automation of AI systems from ISO 22989, which distinguishes seven levels of automation from "Level 0: no automation" to "Level 3: conditional automation" and "Level 6: autonomy" (ISO/IEC 22989:2022). For the traffic light scale used here, the first two levels are grouped as **low automation** (red). Levels 2 to 4 are grouped together as **conditional automation** (yellow). The final level of **full automation** (green) represents levels 5 and 6. The use cases are assigned to the automation levels in expert workshops following the presentation of the results.

Table 2. Use cases in rough, detailed and implementation planning for the use of ChatGPT

| Process | | Planning Tasks | Inform | Analyse | Optimise | Simulate | Visualise |
|------------------|-------------------------|-----------------------------|--|--|--|--|--|
| | | | | | | | |
| Factory planning | | | Potential of ChatGPT by capabilities | | | | |
| Factory planning | Rough planning | Function determination | Required machines/production steps are proposed on the basis of the work plan | Material flow links can be created on the basis of the functions and routings | - No application - | - No application - | Generation of Latex code to visualise the functional diagram with all areas and flow links |
| | | Dimensioning | Assumptions can be proposed as a basis for calculation | Based on the production program, substantiated calculations for dimensional variables can be carried out | Dimensioning variables can be optimised by increasing other parameters | ChatGPT provides information about adjustments to dimensioning variables in given future scenarios | - No application - |
| | | Ideal layout | Suggestions for efficient material flow and storage concepts to realise the ideal layout | Development of an ideal layout taking into account the material flow and the selected production mould | Suggestions for optimising the material flow to eliminate bottlenecks based on information | - No application - | ASCII code based output of an ideal layout in Chat GPT |
| | Detailed planning | Real layout | Identification of restrictions for the design of the real layout | - No application - | Proposed changes to the ideal layout, taking existing restrictions into account | ChatGPT can suggest scenarios and resulting events for the validation of the real layout | ASCII code based output of a real layout in Chat GPT |
| | | Fine arrangement | Output of similar case and application examples of the fine arrangement | Production data can be used to identify causes and suggest changes | - No application - | Simulation scenarios can be proposed and interpreted with regard to the fine arrangement | - No application - |
| | | Workplace design | Provide information on specific technologies and automation solutions | Suggestions for workplace design can be generated on the basis of ergonomic requirements and tasks | - No application - | - No application - | - No application - |
| | Implementation planning | Implementation planning | Identification of essential project management tasks relevant to factory planning | Creation of schedules (Gantt chart) based on personnel capacity and range of tasks | - No application - | Project scenarios or undesirable complications are issued with suitable measures | Visualisation of a Gantt chart in the form of ASCII or Latex code |

Legend: Low automation Conditional automation Full automation

5.1 Target planning

ChatGPT is suitable for information (fully automated) in the planning activity target planning to roughly formulate the project definition, problem and target description, solution concept and cost framework based on less information about the factory planning project, such as the product portfolio to be manufactured and the reason for planning the factory. In addition, ChatGPT can identify the functional areas of the factory based on the information about the product portfolio to be manufactured and the purpose of the factory. A battery cell factory needs production, social and office space, as well as exhibition and training space. ChatGPT detected this with the two basic inputs to plan a battery cell factory and a short description of the factory. However, the functional area of social spaces, which includes toilets and break rooms for

production staff as well as an area for IT infrastructure, was initially neglected by the AI. The missing functional areas were only added on request. No use cases for optimisation, simulation and visualisation were investigated.

5.2 Preliminary planning

The use of ChatGPT in pre-planning is helpful in many areas and supports planning activities. As an example, location clarification is discussed here. Six factors (strategic alignment, infrastructure, availability of skilled workforce, economic factors, environmental regulations, and collaboration opportunities) that are important for location planning were identified by ChatGPT. In response to the question: "Can you give me more details concerning the location? Can you give me a specific location where I can build my factory?", specific locations were mentioned, such as the Wolfgang Industrial Park in Hanau. By entering specific parameters for the plant, such as a floor area, a suggestion for the choice of location was even made and justified (Figure 3). Weaknesses in ChatGPT were particularly evident in the estimation of demand, as the estimated area of a battery production facility was estimated to be significantly larger than the existing factories, and a reduction in size was denied when asked, although some measures were suggested as to how a factory with a smaller footprint could still be planned (e.g., vertical expansion).



Figure 3. ChatGPT's reasoning for selecting a plant location.

5.3 Rough planning

In rough planning, ChatGPT can be used to support the skills of a factory planner in several ways. In the context of function determination, ChatGPT can analyse functional units and routings to create material flow relationships. These in turn can be used as input to generate Latex code to visualise a complete functional diagram. In the context of dimensioning, ChatGPT can perform well-founded calculation steps to estimate the required dimensioning variables (area, manpower, etc.) based on an existing production programme. In addition, ChatGPT can anticipate possible future scenarios and the associated adjustment of dimensioning variables. As part of the development of an ideal layout, suggestions for efficient material flow and logistics concepts can be made, which can be considered by the factory planner when developing the layout. When visualising a factory layout, it is advisable to output the result as ASCII code to generate inspiration for ideal layouts (right Figure 4). Generating real images is not recommended in this case as ChatGPT uses the related OpenAI tool DaLLE for generation (left Figure 4). Although this generates aesthetically pleasing images, it can in no way match the level of detail required for a factory layout. In the context of real layout planning, ChatGPT can assist the user in identifying and implementing constraints on the existing ideal layout for the development of a real layout.

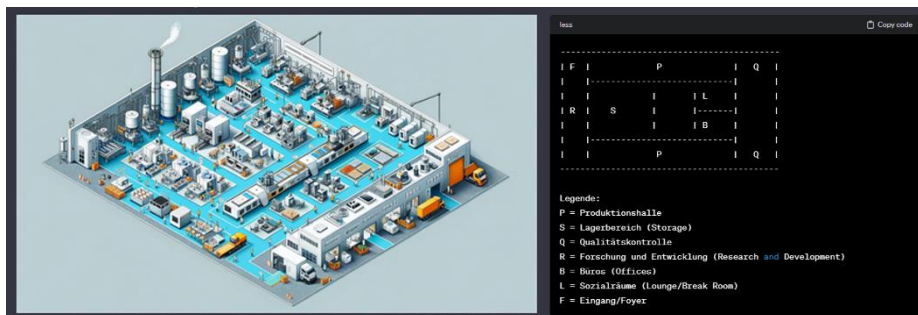


Figure 4. Example of an ideal layout of ChatGPT as an image (left) or ASCII code (right)

5.4 Detailed planning

In the detailed planning phase, the ChatGPT chatbot can be used, for example, for workplace design. ChatGPT can be used to list ergonomic requirements and generate initial suggestions for workplace design. ChatGPT can also be used to provide information about existing automation solutions. In general, it can be concluded at this stage that there are generally use cases for the application of a chatbot, but that these decrease in this phase due to the company-specific level of detail.

5.5 Implementation planning

The use of ChatGPT in execution planning is limited mainly to organisational activities. For execution planning, tasks can be defined, or schedules can be generated. The problem with the visual representation (as with the rough planning – chapter 5.3) is that aesthetically pleasing images of schedules are generated, but these do not correspond to the requirements and the schedule. Again, output as ASCII or Latex code is recommended.

6 Conclusion and Discussion

Companies are faced with the challenge of producing cost-effective products in the face of global competition. The design process is of great importance as it determines a large part of the costs. The design process is labour intensive. Many companies are therefore attempting to support this process to reduce search times and improve design quality. The use of AI technologies offers a starting point for reducing costs and increasing efficiency. However, many companies face the challenge of not being able to develop their own AI solutions due to a lack of capacity. The use of existing tools and solutions is therefore promising for many companies. This paper explores the use of ChatGPT for factory planning.

This study analysed the phases of factory planning and defined the inputs and outputs of the phases. Based on existing experience in factory planning and an example of a battery cell factory, prompts were created in ChatGPT. The goal was to solve a planning process within factory planning with the help of the chatbot. The results of the analyses were recorded in the form of a use case matrix for the application of GenAI in factory planning. Five capability levels (inform, analyse, optimise, simulate, visualise) were evaluated for the planning processes.

In total, 42 use cases for GenAI in factory planning have been identified in this paper. Among them, 11 use cases have the potential to completely automate entire activities. At the same time, 25 use cases were identified with a medium degree of automation and six with a low degree of automation. The findings showed that using ChatGPT is particularly beneficial for initial information retrieval and provision. It was also shown that, for example, location suggestions can be generated and even compared with other locations and a recommendation can be made. At the same time, the creation of an ideal layout, for example, has shown that although aesthetically pleasing images can be generated, they deviate significantly from the requirements of a layout.

Further research is needed into combining ChatGPT with other tools to enable further processing of the code in domain-specific tools. Image generation also needs to be further improved, for example to generate realistic 3D layouts from 2D layouts. There is also the challenge of data security and privacy, as the use of sensitive design data should not be accessible to external parties. The extent to which ChatGPT can support interdisciplinary collaboration also needs to be analysed.

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