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A Process Modelling Morphology to Support Process Analysis and Development in Change Processes

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Abstract

Process modelling (PM) is used to support designers by providing guidance on what needs to be done. Change processes in development organizations accompany introduction of new procedures, new methods (also digital form), tools that have to integrated into existing processes. Objective of this paper is to provide guidance to designers in selecting the appropriate PM language to support structured changes in processes. Requirements are derived from frequent change needs in SME and a PM morphology is provided assisting the selection and use of suitable PM languages for change processes.

Keywords: *process modelling, design process, change management, information management, design methods*

1. Introduction

Engineering design (ED) activities are supported and guided by processes, methods, and tools. Revision of processes and application of methods in ED is becoming increasingly important as design activities are getting more complex and involve more stakeholders (Hjartarson et al., 2021). Since engineering in most cases is an interdisciplinary approach and with strongly interacting activities, process models need to be synchronized at different levels of detail (Bavendiek et al., 2017). Process models are used to present insights on information flows, responsibilities, tasks, milestones, (sub-) activities as well as artefacts to be delivered. In practice, processes are often undocumented and thus not transparent for the various actors involved. This results in challenges especially when process flows, methods, tools, or roles change over time and the actual state can no longer be retrieved. Therefore, processes should be designed flexibly and have to be adapted to complexity and different situations (Lindemann, 2003). Process modelling (PM) languages enable to generate process models needed to represent the actual state as well as intended changes. A change can be, for example, the integration of new design activities for a more system-oriented development to cope with the increasing product complexity in early design phases. At the same time, interactions and relationships between processes and methods need to be considered in change processes (Bavendiek et al., 2017). For tailoring of processes to project specific requirements as well as the assessed level of risk, there are different generic procedures (INCOSE, 2015). However, systematic improvement and adaptation of processes in a change process is rarely established in practice (Lindemann, 2009). The challenge is that due to the fast-moving nature of internal and external process influences, the requirements for PM are constantly changing. This complicates the selection and use of PM languages. The basic assumption of this paper is that change processes in development organisations should be supported by systematic process analysis and modelling. The main objective is to analyse which kind of PM is suitable for a comprehensible sequence and interaction of necessary development activities in change processes.

1.1. Contribution and Methodology

A variety of modelling techniques have been developed over time, but PM has proven particularly useful for using an incomplete representation of reality to coordinate activities, information, stakeholders, and resources in complex development processes (DP) (Helten et al., 2021; Eckert and Clarkson, 2010). To support process analysis and selection of appropriate modelling techniques in change processes, in this paper we propose a selection guide for PM languages following the morphology of Andreasen (1994). This overview is intended to provide a first characterization of modelling languages and thus to support the selection of suitable modelling languages within change processes. To characterize the modelling languages in change processes, the first step is to define change scenarios based on two perspectives (top-down, bottom-up) and to explain how these scenarios are selected. From this, requirements for PM are derived, which are linked as a basis for the basic characterization of PM languages using Andreasen's (1994) model morphology. Ten analytical PM languages are selected based on a review of key process models in design and development (Wynn and Clarkson, 2017). Analytic models are analysed because they are suitable for detailed representation and analysis of improvements in (modified) DP (Trauer et al., 2021). As a result, this paper uses an exemplary change scenario to develop an initial proposed selection guide that recommends 4 of 10 PM techniques for this scenario. This selection of PM languages is suitable for structuring and representing processes under changed conditions and interdisciplinary collaboration of process actors. In this change scenario, the analysis for 6 out of 10 PM languages showed that they are not suitable to represent the required information flows, interaction points between actors or quality output. The reported research work is part of the prescriptive phase of the Design Research Methodology and therefore no evaluation takes place.

1.2. Research Question

Modelling languages for process models are important to coordinate adaptions. Core task of these change processes is the management of dependencies between activities (Wynn and Clarkson, 2017). It is important for organizations to appropriately select the type of PM to support adaptations of processes. The focus of this work is to develop an initial characterization of PM languages to be used in change processes. This results in the following research questions:

- How can change scenarios be described to derive requirements for PM?
- What are basic requirements for the use of PM languages in change processes and what are criteria for their selection?

A brief overview of the basic understanding of PM and its use in development and change processes is given in Section 2. Section 3 describes the selection of PM languages in change processes by going beyond the morphology of change scenarios and defining requirements for PM. The initial characterization of PM techniques is exemplified and discussed by the proposed selection guide for PM in change processes following Andreasen's (1994) morphology in Section 4. Section 5 provides a conclusion and an outlook for future research.

2. State of the art

Process models are among the most significant artefacts to manage design and development projects. Selecting effective PM techniques is challenged by the variety of existing process models for different modelling purposes (Trauer et al., 2021). Paetzold describes the basic framework for data and information flows in development. Here, effects and modelling activities are structured into a macro and micro logic. The macro logic design of processes follows a phase structure (e.g. planning, designing), while the micro logic design of processes considers the level of concrete task processing. (Paetzold, 2022) This section introduces the basic understanding and use of process models in ED as well as their role in change processes.

2.1. Definition and Use of Process Modelling in Engineering Design

Processes are part of the organization's ecosystem and embossed by the basic methodology, principles, as well as company and industry specific standards. Processes are sets of activities carried out with the

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help of resources such as personnel, methods, software tools, equipment, etc., as well as their linkage via information, to achieve a specific goal (output) under given boundary conditions, starting from an input situation (Lindemann, 2009; Inkermann, 2021; Browning et al., 2006). Processes are interwoven by different subprocesses, e.g. describing specific phases of the DP and are affected by as well as define methods, tools (tools for modelling e.g. processes within product development) and guidelines, c.f. (Figure 1). Changes in the existing ecosystem of methods can address different elements of a methodology but become present in adaptions of design activities and thus the PM. Processes, thus, must be understood as a screen for mapping an organisation.

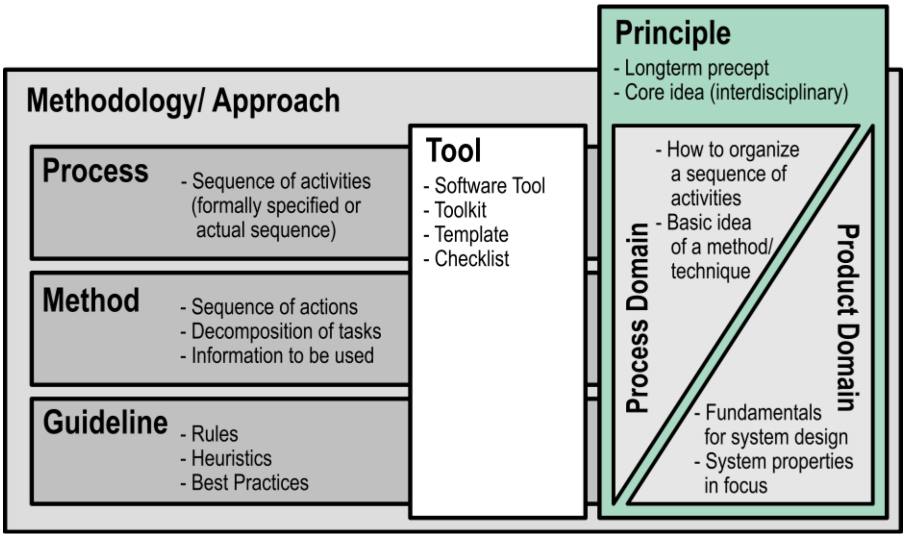

Figure 1. Processes and their interactions within a design methodology (Inkermann, 2021), definitions of the terms are given by Gericke et al., 2017 and Inkermann, 2021.

Complex DP are subject to dynamics that change the conditions defined by the process. Therefore, in a first step current processes within an organisation have to be analysed. In this paper, the focus is on the main engineering processes, as the scope refers to the phase levels (time-recurring elements) and activity levels (recurring elements in terms of content) of the processes. Only when existing processes have been defined, required adaptions and extensions caused by the change process can be determined. In addition, PM reduces the likelihood of forgetting important aspects and serve to communicate and transfer design knowledge and improve communication between the stakeholders in the DP (Gericke and Blessing 2011, in Wynn and Clarkson, 2017). In this paper, an analysis of change scenarios addressing the different elements of a methodology, c.f. (Figure 1), is performed to define requirements for selecting PM techniques.

2.2. Use of Process Models in Change Processes

Complex dependencies of the process elements result from the process structures, which is why the organization and identification of structures within processes (e.g. hierarchical structuring of processes) is necessary. The identification of structures in existing processes thus provides access to process understanding in practical applications and change processes (Lindemann et al., 2009). Process models help to align the stakeholders of a DP and their mental models and thus have the important role as "enabler for coordination" in change processes (Wynn and Clarkson, 2017). Depending on the intended use, different information is needed and have to be represented in a process model. Process models are intended to structure and visualize a process to show interactions and dependencies of activities, results, and responsibilities. Another purpose is process planning, which serves to select activities, design and structure processes, coordinate responsibilities and resources, and estimate as well as optimize key parameters (e.g. costs, duration, etc.). Process models also support process execution and control for progress assessment, process correction and change, and resource control. Process adaption for continuous improvement of a process, knowledge management, staff training, process documentation and quality assurance (Bender and Gericke, 2021; Browning et al., 2006). The application of process

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models in this paper refers to change processes. Lindemann (2003) describes how patterns of processes and methods can support adaptation in changed processes. Thus, the use of process models and patterns supports the user by a given structure to react flexibly to changing situations. As Lindemann (2003) proves through tests with pupils, the use of situational procedures and methods creates transparency and thus even points to process improvement. Further research is needed to interpret the granularity and the way in which the interconnectedness of the knowledge elements is managed.

3. Characterization and Selection of Process Modelling

In this section, requirements on PM to guide change processes are defined. Based on change scenarios in small and medium-sized enterprises (SME), relevant PM languages are selected, analysed, and clustered.

3.1. Requirements on Process Modelling in Change Processes

It is nowadays indispensable to react to changes and thus to adapt, extent and improve processes. Therefore, in a first step it is important to derive possible reasons for changes and derive requirements for PM techniques. Major reasons for process changes can be derived from the processed work of Wickel (2017), Lindemann (2003) and Wynn et al. (2014):

- Process documentation: Different levels of description incl. points of contact for methods
- Change in leadership: Management strategy and loss of knowledge due to personnel changes
- Implementation of new technologies, e.g. new (sub-)systems or process automation
- Changes in organisational culture, e.g. through stand-up meetings or agile structures
- Changed responsibilities and (new) collaborations as well as new roles established in an organization
- Specification of milestones incl. required results and new descriptions of products (models)
- Coordination of information between internal and external stakeholders
- Changes in methods and tools applied within a process

Changes are triggered when a deviation between target and actual properties occurs. A main driver for changes in DP is a shift in value creation. Moreover, changes in the information flow or changing customer and market requirements are frequent triggers of process adaptions (Wickel, 2017). Based on the understanding that changes affect the different elements of a methodology (c.f. Figure 1), the impact on processes, methods, tools, and organisation must be assessed for each change scenario. Accordingly, there are two perspectives to be aware of regarding change scenarios in SME:

1. Top-down: General challenges in existing processes are analysed and carried into pilot projects.
2. Bottom-up: Concrete indications of process changes from operational users in pilot projects.

These two perspectives result in the change scenarios, which are described by more specific requirements and needs to adapt single elements of the given process. The example "change in leadership" addresses the fact that a lot of implicit knowledge is centralized in one person. Thus, this person becomes a central role in the process. As the project team is dependent on the transfer of knowledge the central role can cause delay in decision points. The target here is to transfer the knowledge and to integrate new milestones for decision-making and knowledge transfer in the process. A next aspect is the documentation of processes, which is of major importance. An example is the change in the documentation processes in more detail and integrating methods as well as detailed outputs for a more prescriptive design procedure. The problem here is a lack of common understanding of the process activities and thus the responsibilities and tasks. This leads to difficulties in collaboration and the DP is delayed. Thus, the target is to define uniform levels of process description into which methods can be integrated. Further typical change scenarios, objectives, and derived requirements for PM languages in the change process are given in (Table 1). Starting point in this paper is that an ecosystem of methods (c.f. Figure 1), exists in every company or organization. In the context of a change process, the first step is to recognize that individual elements and their relationships with each other in this ecosystem need to

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be adapted. In the process, it has to be clarified how a process adaptation can be implemented. It is possible to select a modelling technique suitable for a process to introduce the new cooperation in a changed process. PM is necessary to capture, document and simplify existing processes. For this purpose, the next section proposes a selection of PM languages according to Wynn and Clarkson (2017) that are suitable to guide change processes. By visualising and structuring the processes, possible change scenarios can be simulated preventively, and changes can be reacted to.

Table 1. Analysis of change scenarios and derivation of requirements on PM.

Category	Example for a change scenario	Requirements on PM (What can I present in a Process Model?)
Processes	Change in leadership: Bundled knowledge of one person is to be passed on to not slow down the decision-making process	- New process milestones - Required process knowledge - Collaboration (team arrangements, in the form of connections between stakeholders, e.g. information flow) - Process decisions, process activities
	Process documentation: Different levels of description incl. the integration of methods and outputs must be defined in a consistent way	- Artefacts (e.g. process description levels) - Responsibilities - Hierarchical structuring of processes
Methods	Change in leadership: Leadership behaviour and methods depend on the leader and should not change in the way decisions are made during a change process	- New process milestones - Responsibilities
	Change of methods: New engineering methods have to be introduced	- Integration of supporting methods for activities/ workflows - Artefacts (e.g. decision making description)
Tools	Change in leadership: New focus on tool-based solutions; integration of new tools to generate and manipulate product data	- Linked process data and product data - Linking tools into the visual process structure
Organi-zation	Change in organizational culture: The change affects the development of cultural value patterns in an organisation and thus influences the organisational structure and decision-making in interdisciplinary cooperation; decisions should not be delayed	- Information flow - Responsibilities - Process decisions (organisational processes) - Process activities - Process structures (e.g. sub-processes in swimlanes)
	Responsibilities and (new) collaborations: Decision-making is delayed, the nature of decision-making changes and knowledge is redistributed to new people	- New roles and teams - Process decisions - Information flow

3.2. Definition and Clustering of Process Modelling Techniques and Models

In this paper, PM are considered at the meso-level. Wynn and Clarkson (2017) describe this level with a high degree of abstraction that reflects a specific process or company. In this paper, analytical PM languages are selected because SME are largely concerned with meso-level analytical models that require considerable skill and judgement to model (Trauer et al., 2021). To address the challenges and requirements of introducing and using PM languages in change processes, structuring is necessary to identify suitable PM techniques. Wynn and Clarkson (2017) have classified 23 different modelling types for meso-level analytical models into different subcategories (task precedence models, task dependency models or domain integrating task network models, rule-based models, and agent-based task network models). Out of these, 10 are selected and analysed in more detail here (c.f. Figure 2). Two examples of control-flow oriented process models are the Gantt diagram or the BPMN diagram (Business Process Model and Notation).

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	Modelling Languages for Process Models									
	BPMN diagram	**Gantt diagram**	**EPK**	**OPM**	**Process flowchart**	**Task DSM**	**Petri net**	**ASM**	**Design Roadmap**	**IDEF0, IDEF3**
Object	Process activities, process tasks, information flows (gateways), process events, collaboration, sub-processes, artefacts (e.g. documents, data storage)	Process activities, chronological sequence of processes, duration of activities, responsibilites	Process activities, process events, roles, IT systems, risks, data input/output, process documents, process interfaces	Process, entities, objects, functions, events and conditions, links (procedural, structural, control, transforming), object multiplicity expressions and constraints	Sequential process steps, workflow, process decisions, process activities, process documents, data storage	Dependency structure between the product components and process tasks, elements of different domain	Processes models of mainly distributed systems, process activities, memory components, states, objects, or data elements	Process tasks, process interactions, multiple task hierarchies, dynamic behaviour	Process activities, process planning, process relationships between stakeholders, process decisions	Process decisions, actions, activities, process information
Property	Visual representation, possibility of model execution, flow control	Overview of project activities, identification of buffer times	Visual representation event is to be inserted after each work step, the state between two tasks (functions) is represented by an event	Based on a minimal universal ontology of stateful objects and processes that transform them, formal specification	Visual representation of processes or workflows, diagrammatic representation of an algorithm	Visual representation of complex structures or processes (e.g. complex highly integrated product architectures, organizational structures or processes)	Visual representation, modelling in computer science, business processes, mechanical engineering, transitions from states to new states as a description of the state changes	Possibility of model execution, flow control, model-based method, models the precedence and absence of tasks based on their interaction with design parameters	Overview of design activities, identification of buffer times and milestones	Model of process decisions, actions and activities of an organization or system, consider different user approaches on precedence and causality relationships in a process and can include information about the process
Purpose	To map the design processes of different levels correctly and in a structured manner with IT support	Project management tool that graphically represents the chronological sequence of activities in the form of bars on a time axis, to model and visualise project plans	To correctly depict the development process in an IT-supported manner; to depict work processes in a temporal logical sequence using certain syntax rules to analyze and optimize processes	To formally specify the function, structure, and behaviour of artificial and natural systems in a large variety of domains	To illustrate a solution model to a given problem, used in analysing, designing, documenting, or managing a process or program in various fields	To map the relationship between two elements in each case, to be related to each other if they are connected by a comparable type of relationship	To reflect important properties of a system, petri net must represent not only behaviour but also properties of a system	To develop a process overview, to represent the elements in a domain, to explore process behaviour using "virtual experiments", to execute external codes and process decisions, to support planning practice, shows multiple task hierarchies and dynamic behaviour	Outline important phases such as research, creative approach, delivery, and implementation	To structure and describe manufacturing functions, which offers a functional modelling language for the analysis, development, reengineering and integration of information systems, business processes or software engineering analysis
User	Business Administration, Project management, Process management, Controlling, interal and external stakeholders in design processes	Project management, internal and external project partners	Internal and external stakeholders in design processes	Internal and external stakeholders in design processes, large variety of domains	Internal and external stakeholders in design processes	Internal and external stakeholders in design processes	Internal and external stakeholders in design processes	Internal and external stakeholders in design processes	Design Team, Internal and external project partners	Internal and external stakeholders in design processes
Code	Predefined, standardised syntax and symbol semantics	Software-supported representation of project activities	Predefined, standardised syntax and symbol semantics	specified as ISO/PAS 19450	Software-supported representation of documents, data, systems, programs	Predefined, standardised matrix or graph	Software-supported representation of behaviour and properties of a system	Software-supported representation of development processes	Software-supported representation of design activities	Software-supported representation process functions, predefined, standardised syntax and symbol semantics
Medium	Graphical, software-based, multiple layers linkable	Application programmes, such as PHProjekt	Graphical, software-based	Conceptual modelling language and methodology for knowledge capture and systems design	Drawing programmes, such as Flowgorithm or Raptor	Square matrix is used as a modelling basis, which maps the individual elements of the system on the vertical and transverse axes	Network is a graph composed of two types of nodes, called places and transitions, is called place/ transition net	Graphical, software-based, multiple layers linkable	Application programs, tools such as productboard or Aha!	Modelling languages in the field of systems engineering, and is built on the functional modelling language Structured Analysis and Design Technique (SADT)

Figure 2. First characterization of Modelling Languages for Process Models in ED.

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These PM techniques are characterized and structured using the model morphology proposed by Andreasen (1994). The given criteria are allocated to the modelling activity and the resulting modelling language. This allows to match the requirements of the PM used in change processes (c.f. Table 1) with the respective properties of the selected PM languages. Therefore, the modelling languages for process models are characterized in the first step by the following features: object, property, purpose, and user. For the user, a distinction is made between whether PM is used by the user himself or whether the user uses PM as a communication tool to others. For the extended characteristic code, the user's level of knowledge in this environment is decisive, so that the user can decode and understand the PM language. The characteristic medium in which the PM language is created also contributes to the characterization of the process model. The morphology serves as a structuring mechanism for existing PM languages in change processes and support the introduction of the new cooperation of activities, methods, or roles in a change process. Accordingly, (Figure 2) describes the 10 selected process models according to Andreasen's (1994) morphology based on the proposed selected parameters. In conclusion, an initial characterisation for PM languages in the form of clusters can be derived from the analysis. This representation provides the development teams with an overview for an initial classification of their own affected processes during changes.

4. Proposed Selection Guide for Process Modelling in Change Processes

The proposed selection guide for PM languages is intended to support process analysis and development in change processes. The guide connects the 4 evaluation criteria (c.f. Section 4.1) with the PM parameters for a first characterisation of PM languages (c.f. Figure 2). For the evaluation, 3 of 6 parameters (OB: Objective, PR: Property, CO: Code) are selected as examples. If a black dot is set, it is target in the selected criteria category (c.f. Section 4.1). In a first step, the change scenarios are analysed and the requirements for PM are derived and entered in the corresponding cells. Using an example of a change scenario, suitable PM languages are selected based on the defined criteria.

4.1. Evaluation Criteria for Process Modelling in Change Processes

For the first rough characterisation of the PM languages, criteria are defined following Ley et al. (2012). Ley et al. (2012) investigates which criteria exist for measuring and evaluating process efficiency and effectiveness. Wynn et al. (2014) point out the impact of changes in ED on processes. The authors blame this, among other things, on the dependencies between information flows in the product life cycle, which lead to additional effort within the process activities (Wynn et al., 2014). Therefore, information flow is used as an evaluation criteria for PM in this paper. Building on these sources, the focus of the following evaluation criteria for PM in this paper is particularly on interdisciplinary collaboration and the interaction of technical and organisational aspects of engineering projects:

- Information flow (transfer of information) and transparency of information (information is understandable)
- Level of interaction (interaction points between stakeholders, and their responsibilities)
- Process structure (basic sequences, detailing of activities, type of documentation)
- Output quality (quality of the output or artefact of a (sub-)process)

These evaluation criteria are intended to draw attention to the interactions between processes, methods, roles, tools, and information when evaluating PM (Bavendiek et al., 2017) and to guide the change process when characterising PM languages. To concretise the evaluation criteria, they are taken up again here and explained in more detail. Information flow in PM is important in DP and is needed when, for example, the tasks for implementing a change to a subsystem of the DP are to be mapped (Wynn et al., 2014). The focus is on smooth information transfer and transparency of information. However, points of interaction with stakeholders and their responsibilities can also be related to the flow of information.

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Different PM techniques are analysed in terms of the level of detail, the modelling formalism and notation (Gericke et al., 2016), the variety of entities included in the model (Browning et al., 2006), and the modelling approaches itself (Helten et al., 2021). Processes are accompanied by recommendations on how to adapt to changed situations (INCOSE, 2015). Therefore, these changes have been adapted in PM languages. To give an initial assessment of which PM language fits which situation, these 4 evaluation criteria for PM in change processes are detailed by the attributes according to Andreasen (1994) are used in section 3.2. To move from the general change scenarios to concrete requirements for PM, it is first necessary to define which of the four criteria the users are focussing on. For example, if the focus is on information flow, this column in the evaluation table (c.f. Figure 2) is considered for the selection of the PM languages. Therefore, changing information can change the scope and complexity of the process and influence the level of interaction, e.g. in the form of rework of process activities (Wynn et al. 2014). Looking at the object of change that affects the different elements of a process, the main elements affected are sub-processes, activities, data inputs and outputs, decision and control flow elements, resources and tools that support the execution of a process (Wickel, 2017). Therefore, output quality has been chosen as an evaluation criteria. In the next section, using a selected change scenario (c.f. Section 3.1), the evaluation of the 10 PM languages (specification using the attributes according to Andreasen, 1994) is carried out using a proposed selection guide as an example.

4.2. Change scenario-based Selection of Process Modelling Languages

As the selection of PM languages in this paper is based on a proposed selection guide, the first step is to describe a change scenario from (Table 1) and derive the requirements. The exemplary change scenario "change in leadership" in the category "processes" (c.f. Table 1) is selected for evaluation, because these changes occur frequently in the SME environment and in this paper the changed DP are primarily considered. The following requirements for PM (c.f. Table 1: "What can I present in a process model?") have been defined: new process milestones; required process knowledge; collaboration (team arrangements in the form of connections between objects, e.g. information flow); process decision and process activities. Since the focus can vary depending on the requirements and changes, the evaluation criteria "information flow" and "process structure" are selected for the change scenario selected as an example and its derived requirements for PM. Therefore, these two criteria are considered in the proposed selection guide in (Figure 3). For information flow, 6 out of 10 PM languages take this criteria into account. Of these, 4 out of 10 PM languages are particularly recommended, as all three parameters (object, property, code) are fulfilled within the criteria "information flow". The Gantt chart, for example, is less suitable in this change scenario as it is better suited to modelling and visualising project plans (Trauer et al. 2021). Regarding the change scenario, the Petri net places more emphasis on the properties and behaviour of a system, less on roles and knowledge transfer. The process flow diagram is also only suitable to a limited extent here, as the focus is on the flow of the process and thus more on the workflows and the graphical representation. With the criteria process structure, 10 out of 10 PM languages provide guidance for the management and organisation of processes in the development environment and thus illustrate the importance of the structured documentation of processes. Depending on the focus of the user requirements and the selected change scenario, PM in this criteria area is good or very good. The proposed selection guide (Figure 3) is therefore an initial characterisation proposal for selecting a PM language in change processes depending on the focus of requirements. According to this, for example, IDEF0/IDEF3 would be particularly suitable within the criteria "output quality" and "information flow", as this modelling language maps different user perspectives and can integrate product information (Eckert et al., 2015).

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	Evaluation criteria in connection with the process modelling parameters (c.f. content Figure 2; OB: Objective, PR: Property, CO: Code; •: If a black point is set, this is a target in the selected criteria category)											
	Information flow			**Interaction level**			**Process structure**			**Output quality**		
Process models	OB	PR	CO	OB	PR	CO	OB	PR	CO	OB	PR	CO
BPMN diagram (Business Process Model and Notation)	•	Different information flows (sequence, standard, conditional flows), flow control	Predefined, standardised connectors				•	Visual representation, possibility of model execution	Artefacts (documents, data storage, swimlanes: lanes with a pool)	•	Process activities, tasks, sub-processes	Transaction, event sub-process, call activity, collapsed/ expanded sub-process, artefacts (predefined syntax and semantic)
Gantt diagram				•	Relationships between project activities	Connection lines	•	Overview and duration of project activities, identifi-cation of buffer times	Connection lines			
EPK (Event-driven process chain)	•	Control flow from top to bottom in a time-logical dependency of functions	Predefined, standardised connectors (e.g. directed arrow)	•	Event and function linkage variants, modelling of (parallel) processes, decisions, process conditions, jumps back to an already executed activity	Predefined, standardised operators	•	Visual representation of events after each work step, funktions and organisational units	Predefined, standardised syntax and semantic	•	Information objects represent a structured data set (input for the execution of a function or output of a function execution)	Directed edges between function and information object
OPM (Object Process Metho-dology)							•	Process planning, formal representation of functional, structural and behavioural descriptions of systems in an integrated model	Modelling with software tools, addition of SysML recommended by Grobshtein and Dori (2011)			
Process flowchart		Sequential process steps, decisions, activities					•	Visual representation of data, documents, workflows	software-supported representation			
Task DSM (Design Structure Matrix)		Visualization and optimization of invisible information flows, interactions and relationships		•	Dependency structure between procuct compo-nents and process tasks, team structures, low-level parametric relationships	Inter-connection of elements in the form of a standardised matrix		Visual representation of complex organisational structures or processes, activities	Activities are listed in the rows and columns	•	Representation of complex highliy integrated product architectures, elements, relationships and artefacts	Predefined, standardised matrix or graph
Petri net					Software-supported representation of behaviour and properties		•	Graphical representations of logic networks (process description and process state changes in a network as a graph)	Software-supported representation (consisting of places (circles) connected by transitions (vertical bars) via solid dots may move) (Wynn et al., 2006)		Modelling of resources required for task execution	
ASM (Applied Signposting Model)	•	Flow control, multiple task hierarchies and dynamic behaviour		•	Interaction with design parameters and task selection based on the basis of stakeholder confidence (Eckert et al., 2015)		•	Process overview, model-based method			Representation of design processes in terms of tasks and their interactions (Wynn et al., 2006)	
Design roadmap								Overview of design activities, identification of buffer times and milestones	Software-supported representation of design activities			
IDEF0, IDEF3	•	Process decisions, information flow of different user approaches	Software-supported representation, predefined syntax and semantics		Recording and presenting the role of information and resources in a process		•	IDEF0 for function modelling, IDEF3 for activity modelling (Wynn et al., 2006)	Software-supported representation, predefined syntax and semantics	•	Modelling of process functions, variables, activities, artefacts	Software-supported representation, predefined syntax and semantics

Figure 3. Proposal for selection of PM Languages in ED.

5. Summary and Outlook

Processes in organisations are subject to frequent change and essential elements of support change processes and the integration of new methods, roles, or additional engineering activities. Since the internal and external conditions for processes are constantly changing, it is necessary to define change scenarios and to select the modelling languages for process models according to the attributes. This paper describes the role as well as the requirements for PM to support change processes. To assist the selection of appropriate PM languages for different change scenarios, 4 clusters to be considered, namely information flow, interaction level, process structure and output quality, were defined and assigned to the attributes of ten PM techniques. The development of the proposed selection guide is based on the literature and initial findings from PM in collaboration with SME. Currently, there are no findings on the applicability and support of the proposed selection guide in practice, as the paper refers to the prescriptive phase of the DRM. Further research will focus on identifying additional change scenarios and developing a process for deriving requirements for PM techniques. Furthermore, it is planned to evaluate the proposed selection guide in practice in a later phase of the research project and thus refine the classification of suitable PM techniques in change processes. Further research on the use of process models in change processes in practice is necessary for this.

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