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WORKFLOW MODELLING AND PATTERNS OF ACTIVITIES IN PRODUCTION COMPANY

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Purpose: The aim of this publication is to present the application of workflow modelling and patterns of activities in production company.
Design/methodology/approach: Critical analysis of the literature. Analysis of international literature from major databases and Polish literature related to the topic under study.
Findings: Workflow modelling involves transforming the actual work process into its schematic representation. The transformation process itself must be based on reliable and structured data, on the basis of which the stages of the work process are recorded at a specific level of detail. And examining employee patterns of activities in workflow systems is a key step in improving the safety and efficiency of work processes. Thanks to continuous monitoring of working conditions, it is possible to quickly respond to threats and eliminate non-compliance. This approach not only reduces occupational risks, but also increases the efficiency of the production process.
Originality/value: Most research on workflow modelling is applied to information systems. What is new in this article is that the author discusses workflow modelling in production company. In addition, the workflow system has been expanded to include patterns of activities using Motion Capture.
Keywords: workflow, patterns of activities, modeling, work process.
Category of the paper: Research paper.

1. Introduction

Nowadays, the challenge for enterprises is the ability to respond to changes taking place in the environment, which are unpredictable and lack pattern mechanisms. In enterprises where process management is implemented, the way the organization operates changes (Nogalski et al., 2013), which has a beneficial effect on building a competitive advantage and increasing flexibility to introduced changes (Jha, 2016; Stojcic et al., 2018).

Frederick W. Taylor is considered the forerunner of the process management system, who dealt with the optimization of work methods in terms of reducing production costs and increasing efficiency. His research was focused on identifying activities in production processes, then eliminating unnecessary activities and rationalizing the ways of performing necessary activities (Grajewski, 2012). It is worth noting that Taylor divided the process implementation into stages (Grajewski, 2012), starting from getting acquainted with the current state of the company, then analyzing work processes, developing a process map, ending with the implementation of the proposed changes and their continuous observation and modification (Grajewski, 2007). Comprehensive process management is cyclical and deals with the flow of work, documents and information using various tools and techniques (Nogalski, 2010; Tayyaba et al., 2024). This cycle was included by Willam Edwards Deming and Walter Andrew in the PDCA model (Moen, Norman, 2009). The name of the model comes from the first letters of the words: plan, do, check, act (Fig. 1). The result of the PDCA cycle is a graphical representation of workflows, which is supplemented, among others, by: document models, models of organizational structure, models of IT systems used in processes and sets of applicable rules in the enterprise (Gawin, 2015). The next stage is the implementation of the designed workflows into the enterprise structure using workflow.

The process approach in the company has a positive impact on the improvement of the decision-making system and responsibility for the implementation of tasks.

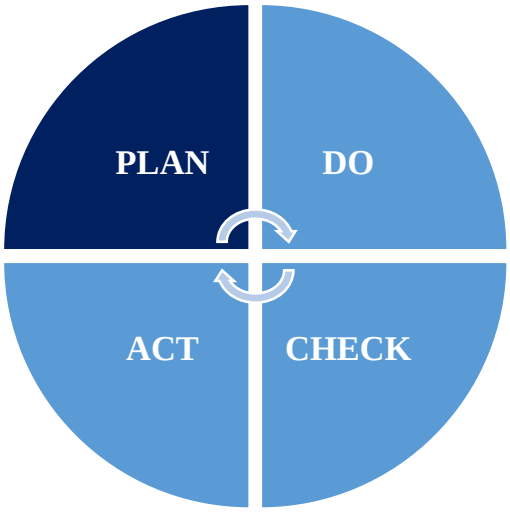

Figure 1. PDCA cycle.

Source: own study based on Meon, Norman, 2009.

The purpose of this publication is to detail the application of workflow modelling and patterns of activities in a manufacturing company, taking into account the specific industry, challenges and benefits of implementing these tools. The publication aims to describe the theoretical basis and methodology of workflow modelling.

2. The concept of workflow

Workflow is a multidimensional concept and has many ambiguous definitions, which are created by combining two words from the English language: work and flow. In 1999, the WfMC (Workflow Management Coalition), which is responsible for standardizing concepts related to workflow processes in enterprises, developed a definition of the concept of workflow in English. The definition is as follows: "workflow is the automation of a business process, in whole or in part, during which documents, information and tasks are transferred from one participant to others to perform an action in accordance with a set of formalized rules". Figure 2 shows a graphical interpretation of the definition of the workflow concept.

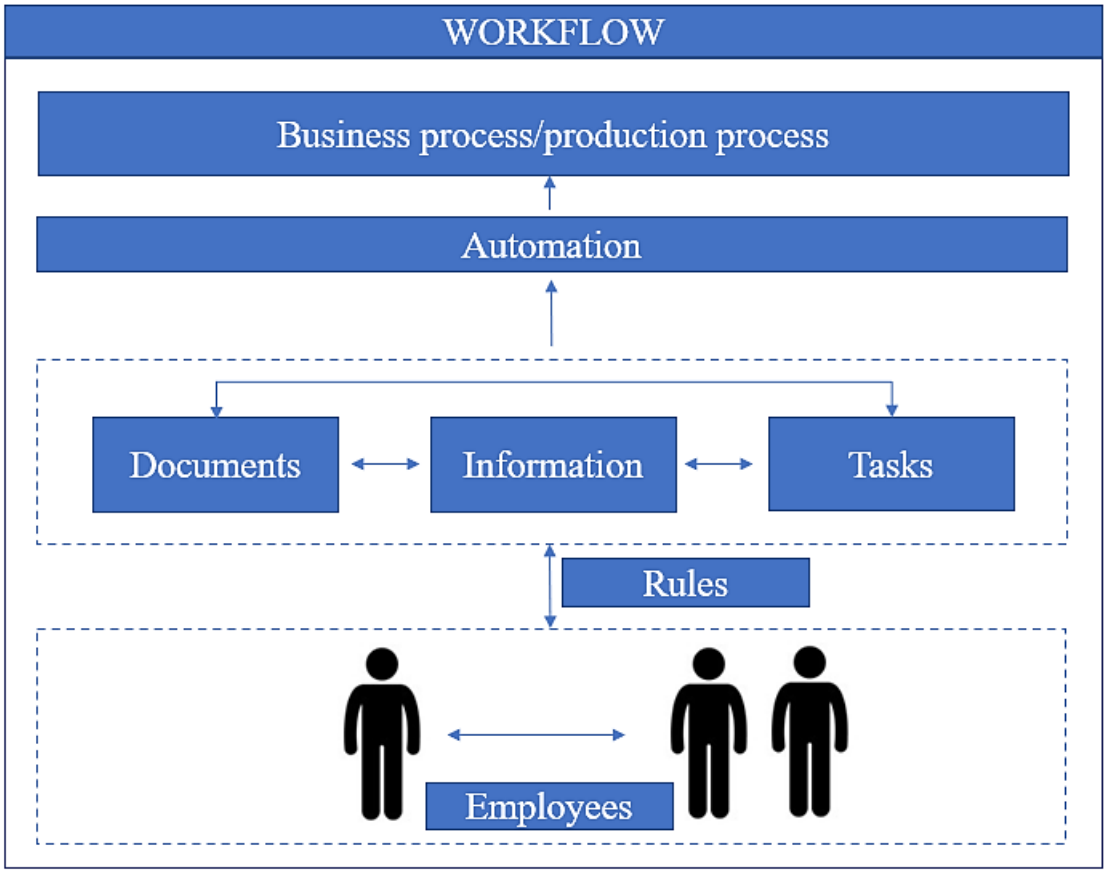

Figure 2. Graphical interpretation of the definition of the concept of workflow.

The most important element of the concept of workflow is a business process understood as modelling the flow of the production process with related tasks, which operates in every industrial plant and leads to achieving the designated effect (Gospodarek, 2009; Volery, Tarabashkina, 2021). A characteristic feature of workflow is a defined, repeatable functional and time structure of tasks (Bartnicka, 2020) and a specific role of people participating in the production process (Bartnicka et al., 2023). Moreover, all documents, information and tasks are transferred to participants in accordance with the formalized rules applicable in the company in

order to perform activities (Raczko, 2009; Cloutier, Langley, 2020). Based on the definition of workflow, the production process can be carried out manually or automatically, depending on the type of tasks performed, thus influencing total or partial process automation and process standardization.

3. Workflow modelling

The most common and widely discussed component of workflow in the literature is modelling of workflow processes. The work processes presented in graphical form along with their parameterization and simulations can be used to improve the efficiency of production processes and improve working conditions in industrial enterprises (Matuszek, Jasik, 2008; Skrzypek, 2010; Prorok, 2017).

Two types of workflow models describing the production process have been recognized in the literature:

- models based on video recording of work processes (Hu et al., 2020),
- models based on the analysis of activities performed in work processes (Gödri et al., 2019; Maksym, 2011).

Models based on video recording of images mainly concern the area in which the selected work process occurs, and the image is obtained from an industrial camera. The video recording is a source of information about the frequency and length of use of tools and devices used by the employee. Additional information obtained from workflow analysis is the identification of states of somatic relations defining the positions adopted during the implementation of work tasks.

The second modelling method is based on the analysis of activities performed in work processes. The workflow model represents individual stages in work processes through the activities performed. This method of modelling workflows has holistic features because it aggregates work processes occurring during production and determines the degree of similarity between them. Moreover, it is used to determine the degree of burdensomeness of work tasks performed in work processes.

The types of workflow models presented are aimed at organizing information related to the implementation of work processes, focusing mainly on such aspects as the type and method of performing activities as a function of time, the type of tools and devices used, and the division of the work process into stages and activities.

Transferring the PDCA cycle to the practical level for modelling workflow processes, we distinguish 4 basic stages (Fig. 3).

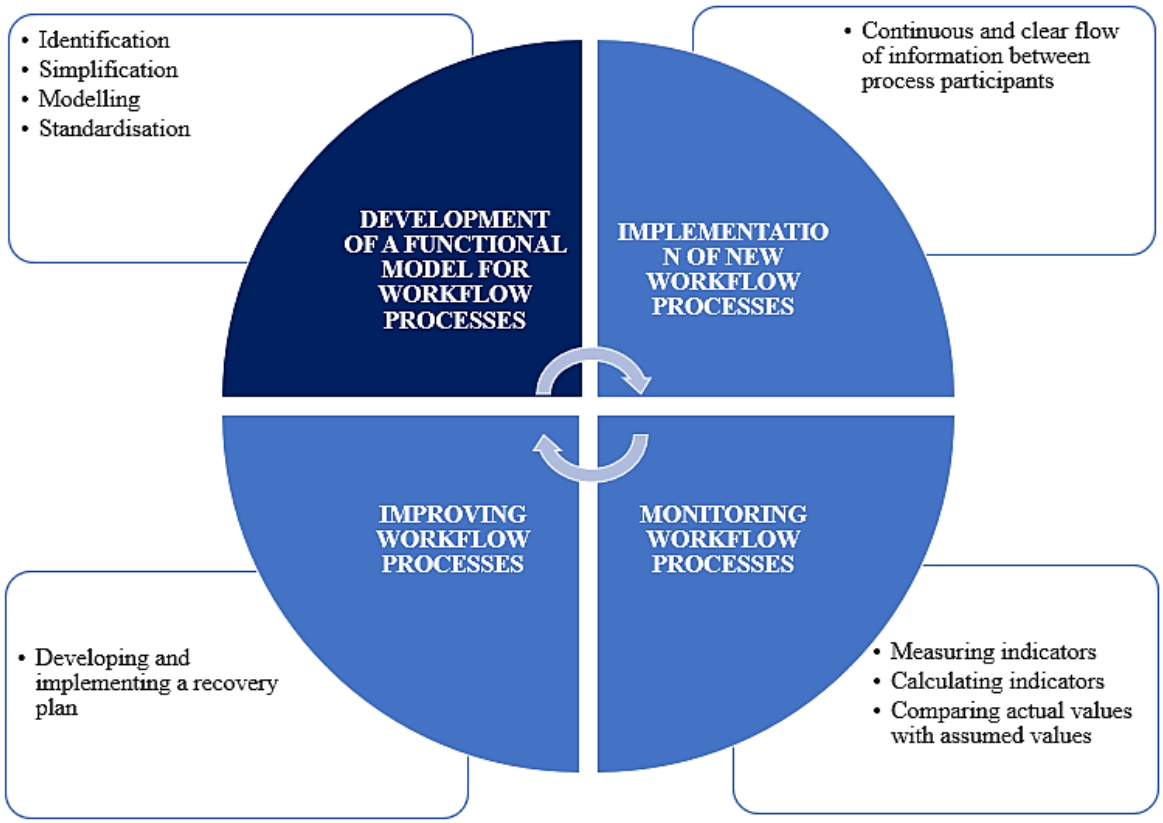

Figure 3. Using the PDCA cycle to model workflow processes.

The development of a production process flow model is based on: identification, simplification, modelling and standardization of work processes (Fig. 4).

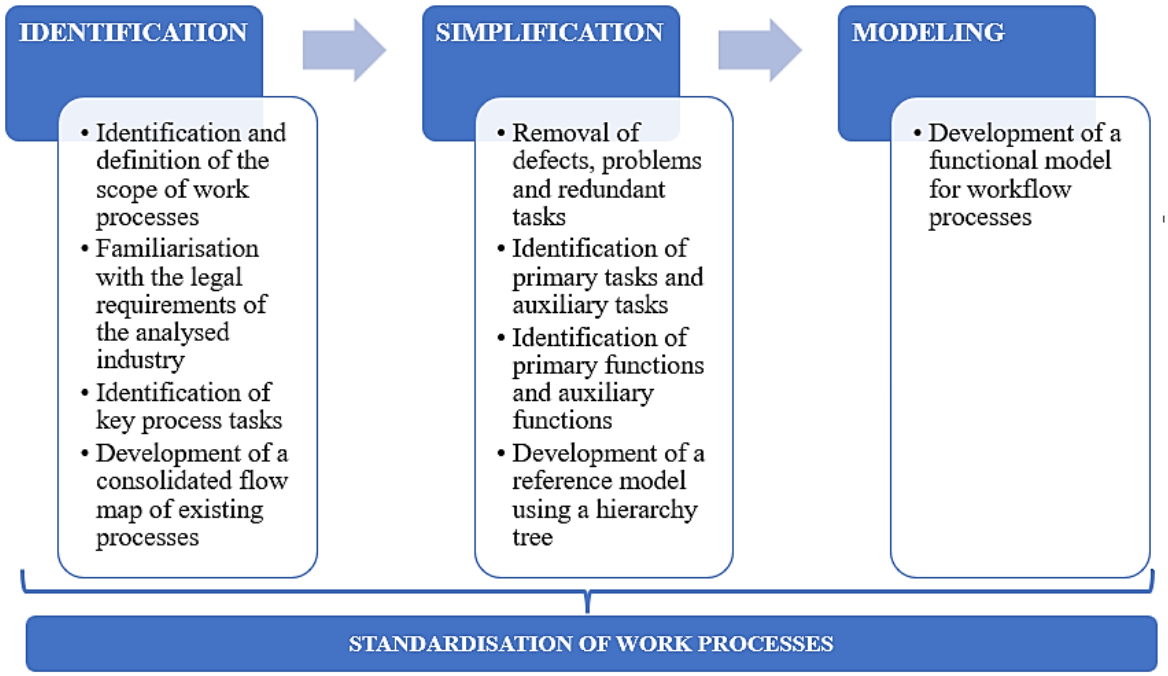

Figure 4. Stages of functional modeling of workflow processes.

Identification begins with identifying and defining the scope of work processes in the analyzed production process, and then conducting a study of the legal requirements for the selected industrial sector. The next stage is to isolate key tasks that have a direct impact on the work processes, as well as to learn how they are implemented, identify inconsistencies and highlight similarities. In order to better understand the analyzed work processes and take into account all the interactions that take place in them, a series of interviews should be conducted with employees in engineering, technical, managerial and worker positions. After conducting extensive research identifying work processes, the final stage is the development of a consolidated process map. The purpose of identification is to understand the connections and dependencies between tasks and to learn about the flow of processes in the enterprise. The next step in developing the model is to simplify existing work processes by eliminating defects, problems, unnecessary tasks, and focusing on the added value in the form of improving the efficiency of workflow processes. The basis for simplification is the division of the main process tasks (i) into auxiliary tasks (ii) and the development of a reference medal using a hierarchy tree from which the main functions (fi) and auxiliary functions (fii) can be read (Abollado, Shehab, 2018). Each main and auxiliary function makes a significant contribution to the process, and prioritization has a significant impact on flow modelling. The result of these activities is to ensure the continuity of work process flows through the feedback loop illustrated in Fig. 5. The presented modelling approach assumes that, based on information from the feedback, process owners make decisions regarding the type and scale of changes undertaken in the process (Gawin, 2013). The implementation of the main tasks (i) and main functions (fi) of the process entails the implementation of many auxiliary tasks (ii) and auxiliary functions (fii), which cannot be omitted. The main functions of work processes include ensuring safety, quality and production efficiency (Galata, 2007). After creating the hierarchy tree, the next step is to determine the connections between the model functions and between the key tasks that need to be performed in the work processes. Identified connections between functions in the overall context create information about work processes, the so-called workflow process model. Standardization occurs in the above-mentioned stages of modelling the flow of the production process, i.e. identification, simplification and modelling. It involves striving to create unified rules for performing activities using a repeatable operating pattern, which will ultimately shorten and achieve higher efficiency of the production process.

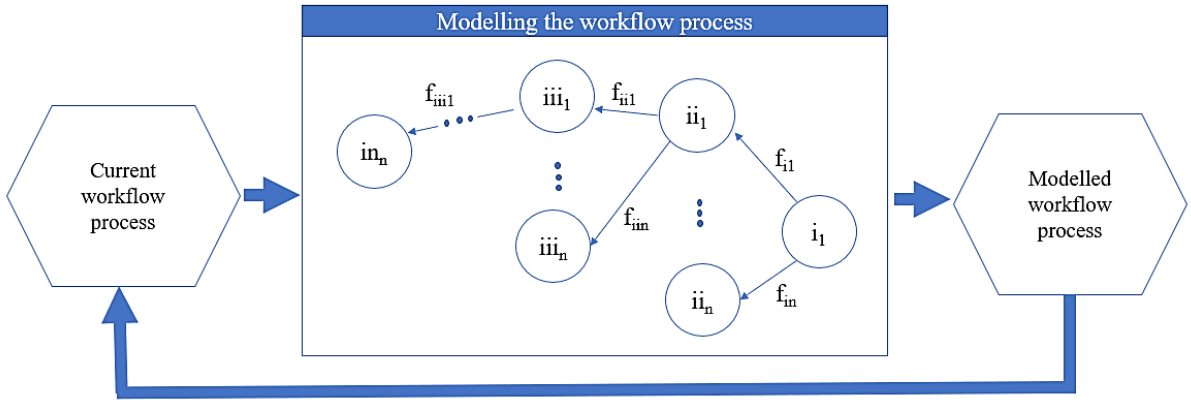

Figure 5. Workflow process modeling diagram.

The next stage of the cycle is the implementation of the developed functional model of workflow processes in the target environment. At this stage, communication between process designers, contractors and recipients should be clear and continuous. The quality of preparation of process documentation, which should be available to all process participants, has a significant impact on the course of process implementation.

The third stage of the PDCA cycle concerns ongoing monitoring of work processes. The most popular way of observing processes is to control quantitative indicators defined in selected places of the process model (Skrzypek, Hofman, 2010; Matuszek, Kurczyk, 2013, 2014). Work process measures are numerical in nature and present the values of a given parameter, such as the task completion time, the number of movements made by the person operating the production process in a unit of time, the number of products made in a given unit of time. The obtained measurement values allow the calculation of indicators that are compared with reference values established at the level of modelling workflow processes by management staff. If the actual value is exceeded (e.g. the task completion time is too long), people responsible for process continuity start analyzing the information obtained in order to develop a recovery plan enabling the achievement of the assumed indicator values.

The workflow modelling described above does not have a final stage that would clearly constitute an ending, because in order to keep up with the changing competitive market, the company should observe the implemented work processes and modify them and draw conclusions to improve efficiency. The obtained effects constitute a starting point for further improvements, and thus for removing the causes of inefficiencies in processes, eliminating disruptions and defects, identifying better solutions and selecting the best one. It can therefore be said that workflow modelling is a process of continuous improvement of an intelligent enterprise.

4. Study patterns of activities in the workflow system

Due to the ambiguity of the definition of workflow and its wide application, mainly related to workflow management, many directions of system development arise. One possibility is to expand the workflow system with patterns of activities (Su et al., 2020) and then develop a set of rules for employees' reactions to stimuli based on patterns of activities. Recognition of patterns of activities, an important aspect of which is the standardization of human behavior in the workplace, is carried out using an image capture system, including motion capture (Condell et al., 2006). In particular, Motion Capture systems enable the recognition and recording of changes in the position of body segments, as well as the collection of information about the sequence of behaviors, their purpose, environment, time, place and achieved effects. In other words, it obtains data about people's behavior as a sequence of events in which we distinguish many factors at the same time. The end result is the development of a map of current behavioral patterns, i.e. repetitive human behavior in a specific situational context in the workplace, which is necessary for modeling employee behavior. Patterns of activities include information about (Longbing, 2010):

- sequences of movements performed by the employee indicating activity,
- the space in which the activity is performed,
- purpose of activity,
- limitation of activity,
- effects of activity,
- duration of activity,
- context of activity,
- connections with other activities.

After developing a map of current patterns of activities, their detailed analysis is carried out in order to isolate standard and desired patterns of activities, which are implemented into the workflow system. The basic task of an extensive system is the ability to correctly learn everyday behaviors based on large amounts of data and the ability to predict, because standard behaviors may persist or change (Dawadi, Cooka, 2016) (Fig. 6).

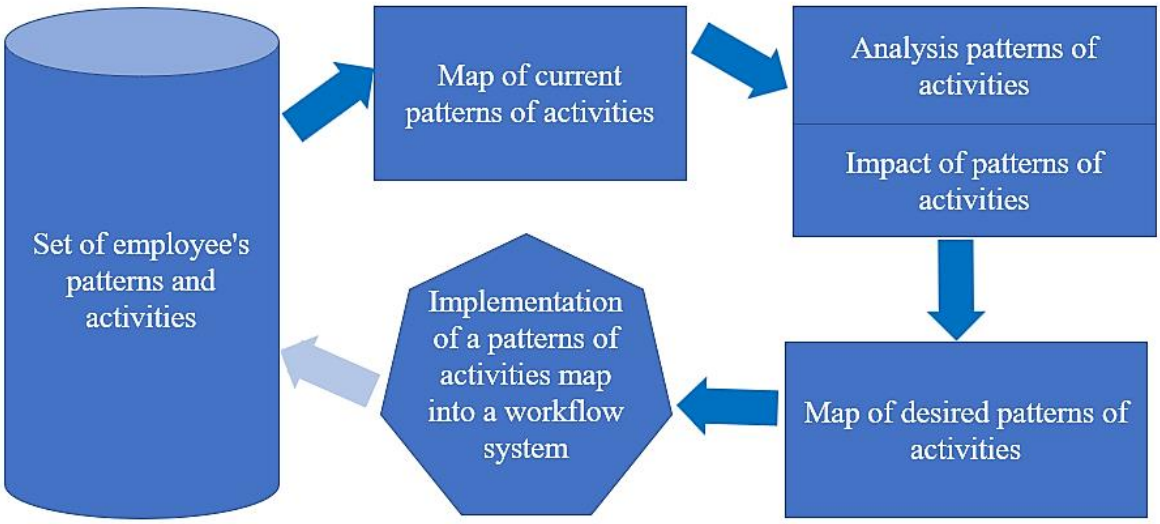

Figure 6. The process of implementing behavior patterns into the workflow system.

This approach to modeling the workflow system using the study of the patterns of activities can be used in automated enterprises to effectively manage security and improve the efficiency of work processes. The role of employees in the production process will always be important, and human-machine communication with the integration of modern technologies, such as the Internet, Big Data, and computer simulations, is essential to the success of the company. In traditional companies, production lines are focused on producing one or several types of products, and the safety of people operating the machines is easy to monitor because the hazards are predictable. However, in modern enterprises, there are many new threats to workers due to the reorganization of production areas, including rapid changes in tooling and even physical movement of equipment, which pose a number of safety challenges. The key task of an enterprise is to ensure the safety of employees, hence an extensive workflow system can help control the correctness of task performance (Bartnicka, 2013). As an example, the following solution can be cited: when an employee finds himself in the machine's operating area or puts his hand in the wrong place (behavior that deviates from the pattern of behavior in a given situational context), the machine will stop, which will reduce the likelihood of an accident. It is worth adding that the most common cause of accidents at work is the haste and inattention of employees, which leads to injuries in the form of crushing and cuts to the upper limbs. In addition, an extensive workflow system can be used to improve the company's efficiency because it is able to predict the consequences of actions, which will improve the response of employees and shorten the time of solving problems. In other words, the employee will be informed in advance about running out of components or a machine jam. This system will minimize losses resulting from unplanned downtime and reduce the costs of servicing the installation or production line. Additionally, it will facilitate the detection of recurring problems and identify the most dangerous activities performed during work processes. An extensive workflow system can optimize the workload of employees at work stations by recognizing the

set of activities performed at work stations and distributing the work evenly throughout the entire working day. All these activities are intended to support the development of working conditions in production enterprises.

5. Discussion

In today's rapidly changing business world, workflow modelling and activity pattern analysis have become key elements of process management. These processes play an important role in improving operational efficiency, change management and technological innovation in organisations.

Research on modelling workflow and activity patterns often focuses on simplified models that do not always reflect the complexity of real work processes. These models are based on theoretical assumptions that are not always applicable in practice (Van der Aalst, 2013). Such an approach can lead to a misunderstanding and inadequate solution of problems that occur in real work processes. Another important limitation is the lack of adaptability of existing workflow models. These models are often static and do not take into account the dynamics of changing work processes (Reijers, Mans, van der Toorn, 2009). Their lack of flexibility to adapt to real-time changes limits their practical application and effectiveness in a dynamic work environment. The lack of consistency and integration between different workflow modelling tools is also a problem. These tools often operate in isolated systems, making it difficult for them to be compatible with each other (Dumas et al., 2018). As a result, organisations struggle to effectively implement and manage integrated systems.

Modern research in the field of workflow modelling points to the growing importance of automation and the use of artificial intelligence (AI). AI makes it possible to dynamically adjust processes in real time and predict future activity patterns based on the analysis of historical data. This approach allows for more precise and efficient process management, leading to better operational performance. New approaches in workflow modelling research focus more on end users. Understanding user activity patterns leads to more intuitive and efficient workflow systems (Bartnicka, 2020). This makes business processes more aligned with the real needs of employees and customers, increasing efficiency.

Research into workflow modelling is important for improving the operational efficiency of organisations. By better understanding and optimising processes, businesses can reduce costs and increase productivity (Podolsky, 2018). This enables organisations to achieve better financial performance and gain a competitive advantage in the marketplace. The ability to model and analyse activity patterns is also key in change management. Organisations that can respond quickly to changing market conditions are more competitive and flexible (Eldar,

Fisher-Gewirtzman, 2019). Workflow modelling research helps to identify areas in need of change and enables the rapid implementation of new solutions.

New knowledge from workflow modelling research can be introduced into education and training programmes to educate future process management professionals. This will equip them with the latest methods and tools, which will increase their value in the labour market. Research findings can also influence the creation of policies and standards for process management, which can lead to a more integrated and consistent approach globally.

Workflow modelling and activity pattern analysis are central to modern business process management. Despite some limitations, research in this area provides valuable knowledge that is widely applicable and has a significant impact on operational efficiency, change management and the technological development of organisations.

6. Conclusion

To sum up, examining employee patterns of activities in workflow systems can bring significant benefits in terms of improving the safety and efficiency of work processes. Continuous monitoring of working conditions enables both ongoing and periodic monitoring of the safety status in the enterprise, which allows for early identification of threats and quick reaction of the management staff to remove non-compliance. As a consequence, such behavior reduces occupational risk and improves the efficiency of the production process. Monitoring working conditions should be multi-aspect by carrying out ergonomic analyses, assessing the efficiency of work processes and examining employee patterns of activities. An example of a supporting solution may be the use of the Motion Capture system. However, it should be noted that the proposed system in the company can be used temporarily, i.e. for training a newly hired employee, or as a control to verify the correctness of the patterns of activities in the case of an employee with professional experience.

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