

## KNOWLEDGE REPRESENTATION OF MANAGERIAL COMPETENCES IN VIRTUAL TEAMS AIMED AT ARTIFICIAL MANAGEMENT

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**Purpose:** The aim of this paper is to show an innovative approach to managerial competences measurement which can be used in team management automation. This aim will be achieved by solving the research problem in the field of artificial intelligence implementation to team management.

**Design/methodology/approach:** There are answers to two research questions: how to represent the knowledge of what a human manager does and how to record the knowledge of what a human manager does. The answer was formulated on foundation of the original concept of methodology in management reality and research on human managers' behavior using online management tools as research tools (TransistorsHead.com).

**Findings:** There are two types of findings. Firstly, an original methodology of team management research – the system of organizational terms, developed and tested in the last years. This is also an answer to the first research question. Secondly, the only way is to record what a manager does directly recording his managerial actions which mean managerial competences able to implement in an artificial manager.

**Research limitations/implications:** To implement an artificial manager at least three conditions should be met: a mutual basis for communication for an artificial manager and team members (shared concepts and their meanings), prediction methods of human behavior in teamwork, a possibility of a real influence of an artificial manager on team members.

**Practical implications:** The last 20 years there has been a rapid development of information technology, robotics and replacing people's work with machines or algorithms. Therefore, the area of team management automation and its consequences seem to be dominant area of research in the nearest future as well as practical implementation of this research.

**Social implications:** In the literature and in the public domain an important discussion has started how artificial intelligence will change our social life. The same implications consider the artificial management.

**Originality/value:** The system of organizational terms used to represent managerial competences as managerial actions.

**Keywords:** artificial management, managerial competences, knowledge representation.

**Category of the paper:** Research paper.

## 1. Introduction

The last 20 years there has been a rapid development of information technology, robotics and replacing people's work with machines or algorithms. Managers commonly work with electronic tools that facilitate their work registering their work (Ewenstein, Hancock, Komm, 2016), e.g., in organization processes (Dash, McMurtrey, Rebman, 2019), IT sector services (Keller, 2017) as well as team management (Davenport, Kirby, 2015).

From the business perspective organizations must respond more effectively to the dynamic and complex environments today. Therefore, team management have become more and more relevant in the past decades, and they are seen as a key factor in increasing organizational effectiveness (Mathieu et al., 2008). This has enabled modern organizations to look for the advantages of integrating all related activities by the means of teamwork and artificial management (Webber et al., 2019). However, team management processes can lead to the consequences which a human manager as well as team members are not able to foresee (Franken, Wattenberg, 2019).

Therefore, in this perspective the research problem in the field of artificial intelligence implementation to team management can be described as a simple question: how to know the activity of a human manager to replace him with an artificial manager? This research problem implicates two main research question:

1. How to represent the knowledge of what a human manager does?
2. How to record the knowledge of what a human manager does?

Importance of the research problem comes from the fact that effective teamwork becomes a crucial problem in organizations. Its internal elements – a team manager and team members – are the warp and woof of the dynamic fabric of companies. They cannot exist without each other activated by managers to use a constellation of specific objectives, resources, and processes (Sohmen, 2013).

The aim of this paper is to show an innovative approach to managerial competences measurement which can be used in team management automation. This aim will be achieved by answering two mentioned research questions on foundation of research on human managers' behavior using online management tools as research tools (TransistorsHead.com).

As a main term which allowed us to understand what a human manager really competence does was defined as an acquired personal skill demonstrated as one's ability to provide a consistently adequate or important level of performance in a specific job function (Numminen et al., 2020). Therefore, competences of human managers were examined in a few research projects of the authors and the are promising theoretical construct to represent knowledge of what a human manager does as well as quite easy to record by online management tools.

In Section 2 there is a description of fundamental issues of (1) artificial management as a new approach to team management, (2) managerial competences as a theoretical construct used in AI implementation, and (3) virtual teams as an environment of an artificial manager activity. In Section 3 there are (1) theoretical foundations of knowledge representation by the system of organizational terms (an original research methodology created by Olaf Flak) and (2) examples of knowledge acquisition by the online management tools in the platform of TransistorsHead.com. Section 4 contains conclusions and future perspective of team management automation research.

## **2. Theoretical background**

### **2.1. Artificial management**

The first vision of artificial management was spoken in words that in the future “computers” will not only make decisions, but they will do much more (Drucker, 1967). Looking for an answer if it is possible to replace human team managers with robots, terms “artificial management” and “artificial manager” were created (Geisler, 1986). The concept of artificial management and its operational consequence in person of in artificial manager was seen as a dehumanizing attempt to eliminate participation of human managers in the processes of the organization. Therefore, most of researchers considered artificial management applications only in organizational decision systems or routine operational processes which were well structured (Huber, 1990; Mitroff, Linstone, 1993; Pomerol, 1997; Courtney, 2001; Gigerenzer, Gaissmaier, 2011). Eventually, it led to a strong need of establishing some patterns of team managerial work (Halliday, Stacey, 2009) or it is focused on automated decision making (Zimmermann et al., 2019).

However, nowadays AI overwhelms more areas of managerial actions. Artificial intelligence is emerging as a potential growth area for facilitating the improvement and development of teams in the workplace. AI, as used in the team context, is currently underdeveloped and limited, thus reducing the wide-scale adoption and implementation of AI to improve team effectiveness (Webber et al., 2019). New applications such as robotics, automation or intelligent assistance are becoming drivers of a wide-ranging change process in companies which requires reorganisation of team management, particularly in virtual teams (Franken, Wattenberg, 2019).

However, in the literature there are approach to artificial management which representations are an artificial leader or an artificial manager. On the one hand, there is a vision of an artificial leader as an intelligent system which has new dimensions of human-computer interactions based on natural communication patterns and consideration of human individual differences.

It is said that in the future information systems will involve both the automated delivery of human-like communication and the interpretation human verbal and non-verbal messages (Derrick, Jenkins, Nunamaker, 2011). The ability for a computer system to have a knowledge base on which to draw to deliver appropriate messages to a human user is an ambitious undertaking and is a novel conceptualization for information systems. The prospective benefits of AI to the decision-making process before arguing that they can be practicably implemented in a social setting, e.g., if a human leader can veto any decision taken by an AI-based system (Parry, Cohen, Bhattacharya, 2016). There are also philosophical dilemmas about ethical aspects of artificial leadership (Lawless, 2021). Such focus may utilize top-down and bottom-up ethical issues, with decreased focus on getting machine followers to feel part of a virtual team (Smith, Green, 2018).

On the other hand, automation of the role of managers can be seen as a gradual replacement of human managers only by algorithms in some areas of team management and such a system would be called an artificial manager. As a result of this approach nowadays in many organizations some processes are completely managed by AI technologies (Petrin, 2019). Managerial activities have been taken over by machines such as describing tasks, evaluating team members performance, and matching employees in work teams (Jarrahi et al., 2019). It is even said that these technologies can cover the entire spectrum of managerial actions of highly qualified managers (Susskind, Susskind, 2015). Overall, this new AI approach presents both opportunities and challenges within workplace management. For example, in the literature there are many challenges in cooperation of artificial managers (AI management) and human team workers (Peifer, Jeske, Hille, 2022).

## **2.2. Managerial competences**

There are many definitions for the competences, but authors agree that a competence is defined as a learned ability to adequately perform a task, duty or role (Bartram, Roe, 2005). The competences integrate knowledge, skills, personal values, and attitudes, and they build on knowledge and skills and are acquired through work experience and learning by doing. It means that competences rest on the pillars of knowledge, skills, and attitudes and that the whole structure is built upon the individual person's dispositions, i.e., abilities, personality traits, interests, values, etc. They define capabilities to learn the necessary knowledge and skills, the appropriate attitudes and to conduct psychological services for clients to meet the standard expected by their profession.

The descriptions and definitions of competences have been increasingly present in the area of Human Resource Management and replaced the concept of qualifications (Cook, Wildschut, Sande, 2017). In the literature The term "competence" refers to the general competence, the quality of an individual or a set of skills that allows one to perform in certain situations (Anzengruber et al., 2017). Competences refer to a set of traits that influence one on certain

actions, and a specific skill set of activities that one can use to measure and demonstrate the universal competence.

Competences have attracted a lot of research; however, competencies usually have been focused on individual or organizational ability to express effective job performance in the context of expected real job proficiency (Cook, Wildschut, Sande, 2017). Competences are defined as the ability to do the work which means that individuals have the knowledge, skills and values required in jobs of today and tomorrow (Phuc, Matsuura, 2016). In such context competences are defined as acquired personal skills demonstrated as one's ability to provide a consistently adequate, important level of performance in a specific job function (Numminen et al., 2020)

The competencies have unique characteristics or qualities, and they are difficult to copy (Hensel et al., 2010). Additionally, individual competencies contain explicit knowledge, personal skills and experiences with individuals' results and judgement of organizational values which are obtained in their social context (Ubeda, Santos, 2007).

However, significant differences were observed in the effectiveness of managers using task, relations, and changing capabilities. Competencies depend on the organizational context and may be different at various levels of management. For example, at top management level there is a need for more strategic competencies, i.e., change-oriented, which become two to three times more important than at the lowest level. Task-oriented capabilities become significantly less important at the top level and more important at a lower level of management, whilst relations-oriented capabilities are important at all levels (Anzengruber et al., 2017). It is said that the competencies are also shaped by the context of work, work environment, and the employee's personality and motivation (Forsten-Astikainen, Heilmann, 2018).

Competency analysis is an alternative to traditional job analysis and is a method focused on the individuality of the employee. It can be used for selection, training, development, and evaluation. The purpose of competency analysis is to create a profile of an ideal employee or a competency template consisting of a set of characteristics. Such a profile shows what competencies an employee should have to perform his or her duties effectively (Roźnowski, 2020). A competency model is the result of such a job analysis and contains a description of all competencies considered by the company to be necessary for success in its business. They consist of a list of competencies and a detailed description of each of them. In the context of job analysis, competencies are understood as compositions of qualities and states of an employee that lead to optimal performance of tasks on a given job and thus are a set of knowledge, attitudes and personality traits possessed by an employee (Sew, Yahya, Tan, 2019).

As the management activity and its representation aimed at artificial management is concerned, it is necessary to describe teamwork competency. It can be diagnosed by observing the following behaviors: (a) interacting with co-workers, (b) being active in achieving goals, (c) stimulating the motivation of others in the team, (d) communicating information important to the quality of cooperation, (e) dealing with demanding situations (Wood, Payne, 2006).

These five groups of competences we could represent and record by the online management tools implemented in the research platform called TransistorsHead.com, described in Section 3.1.).

### 2.3. Virtual teams

A team is defined as a bounded and stable set of individuals as a group of people who are interdependent for a common purpose or who work interdependently to-wards shared goals (Edmondson, Reynolds, 2016). Thus, teams have two required elements: firstly, membership and, secondly, collaborative tasks.

Firstly, team memberships in the past were often mutually exclusive, with members working on only one team at a time. Traditional teams are co-located and have easy access to both face-to-face and electronic communication. These teams have been formally studied for more than half a century, resulting a huge body of literature (Mathieu et al., 2008).

Contemporary the term membership tends to overlap because members working simultaneously on more than one team. Additionally, today teams are becoming more virtual organized (Salas, Tannenbaum, Kozlowski et al., 2015) than face-to-face due to inter-organizational alliances, globalization, outsourcing and alternative work arrangements (Kozlowski, 2015). These teams are most often constructed because organizations require skills, local knowledge, experience, resources, and expertise from employees who are geographically- distributed.

Secondly, collaborative tasks in teams implies that team members interact and share resources to complete their duties, which means that they are interdependent regarding task accomplishment. Through the years, an increasing number of frameworks have been proposed to provide a classification of teamwork actions such as communication, coordination, and cooperation (Kozlowski, Bell, 2003; Frick et al., 2017). The integrated model of hierarchical conceptual structure of teamwork activities has been presented in which two set of teamwork actions are proposed: focused on regulation team performance (preparation of work accomplishment, task-related collaboration, team adjustment and work assessment) and focused on management team maintenance (psychological support and conflict management).

Virtual teams in organizations appeared in the last decade of the 20th century and they are associated with accelerating business activities and increasing innovations (Fuller, Hardin, Davison, 2006). A virtual team as a group of people who do not stay geographically, organizationally, or temporally in the same place, but co-operate with each other through the use of ICT for one or more organizational tasks (Kozusznik, Pollak, Chrupała-Pniak, 2020). The degree of use of innovative technologies then becomes an indicator of the level of virtuality of such a team (from semi-virtual to pure virtual) (Lonnblad, Vartiainen, 2012).

The virtual team is also described by the category of temporality when short, un-defined time of the team's activity is conditioned by the needs of the organization and individual motivations of its members (Gassmann, Von Zedtwitz, 2003). Virtu-al teams are also found in

organizations which bring together specialists who design and conduct research or collect data (Engerer, 2019). During the COVID-19 pandemic virtual teams appeared in organizations as a necessity to meet the challenges of isolating employees and virtual teams became a hallmark of the pandemic. A few last years have boosted the implementation of virtual teamwork, with many employees working at homes using virtual tools to collaborate with their teammates (Feitosa, Salas, 2020). Therefore, a virtual team we assume as a natural environment of artificial management implementation and in such virtual teams we conducted re-search, as it was described in Section 3.2.

### **3. Research methodology**

The first research question, mentioned in Introduction, concerning knowledge representation of managerial competences, will be answered by presenting a new research methodology based on the original system of organizational terms.

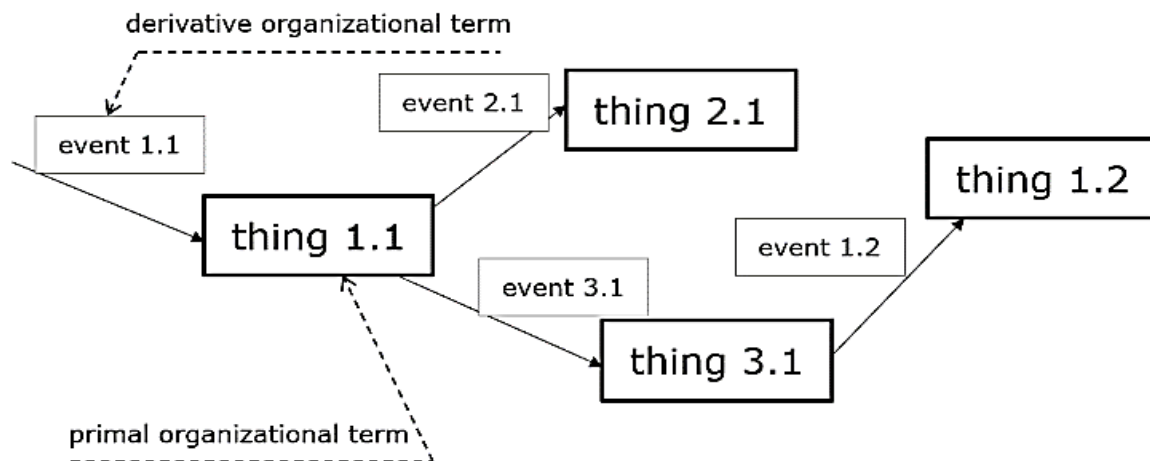
In the management science literature, one can find a full range of publications on knowledge management in organizations. This process is understood as the management of the processes of creating, distributing, and practicing knowledge to increase the efficiency of the organization, especially in the operational dimension. Two types of knowledge can then be distinguished: tacit (Chalmeta, Grangel, 2008) and explicit (Matos et al., 2010).

There is a way of creating tacit knowledge as a result of teamwork but based on the intellectual capital of each of its members and the recipients of activities in the organization. Explicit knowledge is created based on the intellectual capital of the team as a whole and the processes that take place in the organization. Both types of knowledge “span” the human capital and social capital of the organization (Matos et al., 2010).

In the context of knowledge representation of what a manager does, the model of the formation of tacit and explicit knowledge in an organization seems much better (El-Sayed, 2003). It shows four stages of changing tacit knowledge into explicit knowledge and vice versa. The model captures both types of knowledge in a dynamic way. Tacit knowledge, through the process of socialization and because of an individual's choices, transforms into explicit knowledge, resulting in its conceptualization. Then, through the process of combination and exchange, overt, systematized knowledge of reality is created. It transforms again through the individual's learning process, which results in the operationalization of knowledge in the individual. Such knowledge is again tacit knowledge. This is where the cycle begins again (El-Sayed, 2003).

On this foundation and based on the previous research we formulated the answer to the first research question, how to represent the knowledge of what a human manager does. The answer is an original methodology of team management research – the system of organizational terms, developed and tested in the last years (Yang, Flak, Grzegorzek, 2018; Flak, 2019; 2020; 2021). This methodology allows us to record managerial actions one by one and it is possible to answer what a team manager and his team members really do (Sinar, Paese, 2016). Managerial actions are the real and active representatives of managerial competences, according to the definition presented in Introduction. It is worth reminding, that competence is acquired personal skills demonstrated as one’s ability to provide a consistently adequate or high level of performance in a specific job function (Numminen et al., 2020).

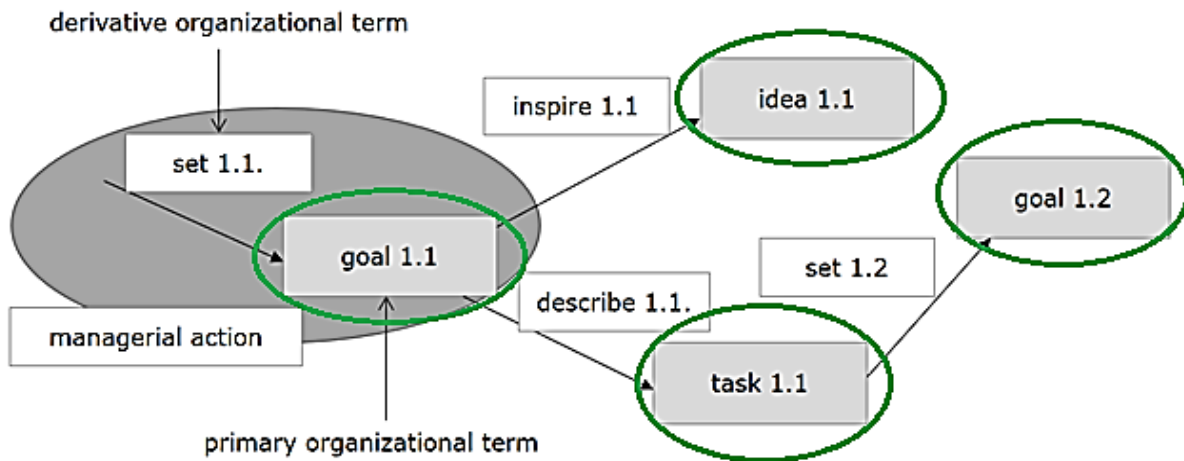
The philosophical foundation of the system of organizational terms is based on Wittgenstein’s philosophy: his theory of facts (the only beings in the world) and “states of facts” (Brink, Rewitzky, 2002). According to this approach team management can be organised by events (derivative organizational terms) and things (primary organizational terms). Specifically, as shown in Figure 1, each event and thing have the label n.m, in which n and m represent a number and a version of a thing, respectively. Event 1.1 causes thing 1.1, which in turn releases event 2.1 that creates thing 2.1. Thing 1.1 simultaneously starts event 3.1 which creates thing 3.1. Then, thing 3.1 generates the latest version of the first event, i.e., event 1.2. In such a way, the latest version of the first thing is created, which is called thing 1.2. So, the managerial action structure consists of, e.g., event 1.1 and thing 1.1. As it was shown in Figure 2, differences between features of goal 1.2 and goal 1.1. let us do reasoning on the team management process (Flak, 2018).



**Figure 1.** Theoretical pattern of events and things.

Source: Flak, 2022, pp. 153-166.





**Figure 2.** Managerial action’s structure.

Source: Flak, 2022, pp. 153-166.

In the research we recognized 10 managerial actions which represented 10 managerial competences in 5 groups which were described in Section 2.2. Table 1 presents managerial competences which build knowledge of what a human manager does. This is the answer to the first research question, how to represent the knowledge of what a human manager does. We can do it by managerial competences, which theoretical construct consists of primary and derivative organizational terms formed in managerial actions.

**Table 1.**

*10 managerial actions representing 10 managerial competences*

Item	Combination of managerial competences in groups of behaviours	
	group of behaviours (Wood & Payne, 2006)	managerial competences (represented by managerial actions taken by managers)
1	interacting with co-workers	generate ideas (3), specify ideas (4)
2	being active in achieving goals	set goals (1), describe tasks (2)
3	stimulating the motivation of others in the team	check motivation (7), solve conflicts (8)
4	communicating information important to the quality of cooperation	prepare meetings (9), choose options (6)
5	dealing with demanding situations	define problems (10), create options (5)

Source: Own elaboration.

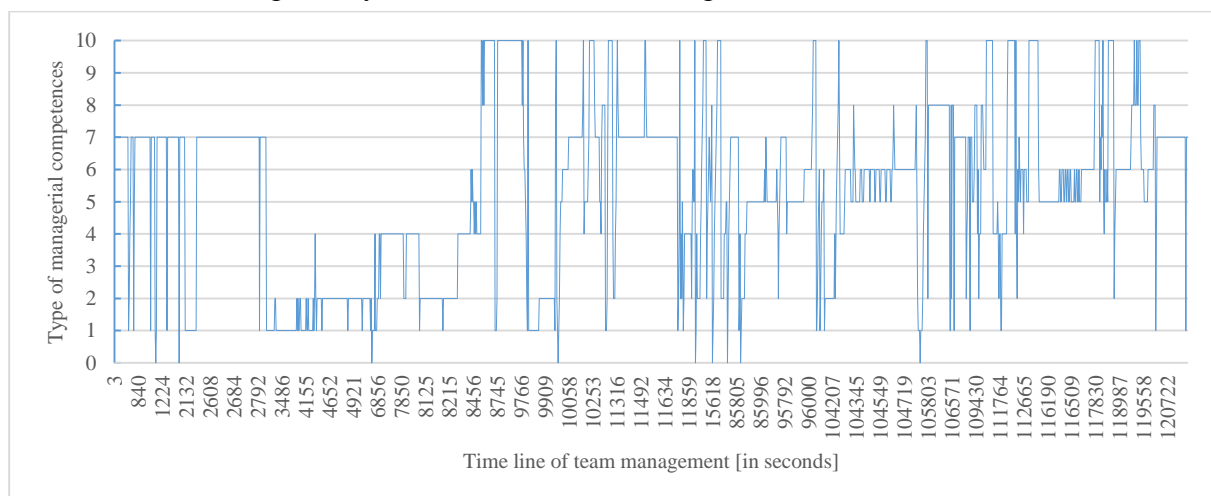
## 4. Research results

The second research question which was how to record the knowledge of what a human manager does concerned knowledge acquisition of managerial competences. However, it is not easy to record behaviors which could mean managerial competences able to implement in an artificial manager. The only way is to record what a manager does directly recording his managerial actions.

So that the research platform TransistorsHead.com was created with 10 online managerial tools being in the same time research tools. This set of online management tools record parameters of the managerial actions (effects marked with a round, e.g., a goal 1.1 because of set 1.1). It reminds making a movie of teamwork with frames of features team management processes. The results of using this approach to track managers' behaviour by managerial competences, checked in empirical research, was described in many previous publications (Flak, 2018; 2019; 2020; 2021; Yang, Flak, Grzegorzek, 2018).

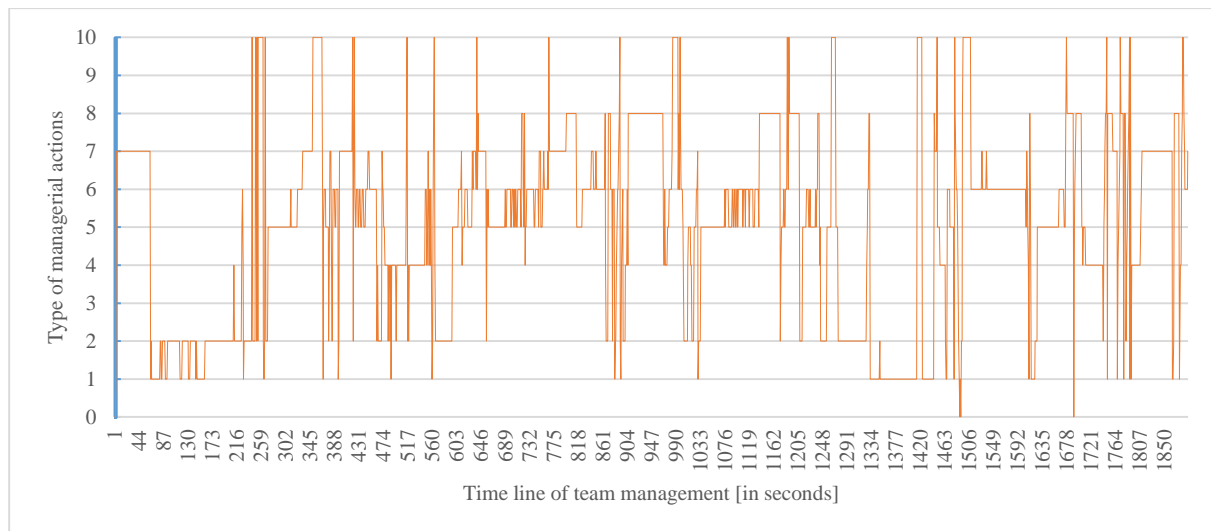
As an example of the acquisition of knowledge on what a human manager does managerial competences, we present the results of the research obtained during a 36-hour non-participant observation on June 29-30, 2021. The group of observation participants consisted of 6 2nd degree students at the University of Silesia in Katowice, working in 2 equal virtual teams. Each team had a designated team manager role. The students had basic competencies in managerial techniques, acquired during courses in the study program. Both groups were given the same task, which was to design an entertainment program in Talent Show format on a YT channel. Participants could work at any time between 9 a.m. on the first day and 9 p.m. on the second day of observation. During the assignment, students used 10 online managerial tools on the TransistorsHead platform and the MS Teams as a communication tool.

In Figure 3 and Figure 4 there are histories of managerial competences used by participants in certain moments of research time by manager 1 and manager 2, respectively. We can see how much they differed from each other when they were managing teams, both focused on designing an entertainment program in Talent Show format on a YT channel. The numbers of types of managerial competences mean the managerial competences indicated in Table 1. As it can be seen, managers used different managerial competences in different time periods and sequences. They had their own managing style consisted of managerial competences which could be repeated by artificial managers. Such research confirmed that the way of recording the knowledge of what a human manager does when used online management tools is efficient and let us build knowledge ready to use for artificial management.



**Figure 3.** History of managerial competences used by manager 1.

Source: Own elaboration.



**Figure 4.** History of managerial competences used by manager 2.

Source: Own elaboration.

As it was shown in Figure 3 and Figure 4, using the system of organizational terms and the representing managerial competences as managerial action, we can answer the second research question, how to record the knowledge of what a human manager does. We can record managerial actions using managerial tools, such as in TransistorsHead.com or many others, to distinguish separate managerial actions to know which competences are necessary in artificial management.

## 5. Conclusions

This rapid development of computer science gives opportunities to replace managers of teams with robots. The area of team management automation and its consequences are dominant area of research in the nearest future (Peifer, Jeske, Hille, 2022). We can find research on influence of AI management on such aspects of team management as planning (Liu et al., 2020), creativity (Parry, Cohen, Bhattacharya, 2016) or decision making (Smith, Green, 2018). However, it still not possible to employ a robot on a managerial position. Why?

In the paper we present answers to two main research questions when we think of implementing artificial management. Firstly, how to represent the knowledge of what a human manager does. Secondly, how to record the knowledge of what a human manager does. The answer to the first question is the system of organizational terms as the research methodology of managerial competences, represented by managerial actions. The answer to the second question is the set of managerial tools implemented in the TransistorsHead.com platform, which can record managerial actions to know which managerial competences are necessary in artificial management.

This approach is more efficient than the traditional approach to competences and their measurement presented in the Theoretical background. It is more fruitful because we can achieve clear histograms of managerial competences sequences used in a certain situation which a manager must solve during projects.

Therefore, in this perspective the research problem in the field of artificial intelligence implementation to team management can be solved by knowledge of human managers' activities which should be replaced with an artificial managers' activities. However, to implement artificial management at least three conditions should be met: (1) a mutual basis for communication for an artificial manager and team members (shared concepts and their meanings), (2) prediction methods of human behavior in teamwork, (3) a possibility of a real influence of an artificial manager on team members.

Taking into consideration these conditions the next research problem to be solved in the future concerns patterns of team management processes in a virtual team. This main research problem can be split to 3 groups of specific research domains: (1) content domain (what are the features of managerial actions), (2) a time domain (when do they happen) and (3) a psychological domain (what are the interactions of managers and team members). Answering to these research questions will be a task for the future research on implementing artificial management in virtual teams.

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