

Increasing the efficiency of research activities management in scientific organizations: a leadership framework

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Abstract This paper analyses the management of the research process in terms of vertical and horizontal leadership. Specific features of research activity are discussed from the point of view of the project management and leadership theory. Group dynamics of research team in different stages are adapted to these features. Our results and implications allow us to identify the most significant criteria for assessing potential horizontal leaders. Different methods of evaluation of team members for their participation in the nomination are considered. The two-side process of identification horizontal leaders is revised due to specific of research activities. We propose pyramid model of research activity management process allowing to cover simultaneously both organisational relationship and research process interactions. Moreover, we discuss the managerial and theoretical implications stemming from this research project.

1 Introduction

The formation of a modern management system for project groups within an organization is deeply connected with evolutionary processes both of management theory and leadership itself, as well as with changes in the image of modern economic activity and approaches to organizational structure.

Production automation processes lead to a shift in the focus of management from the functions of planning, rationing and quantitative control towards targeted management, motivation and quality control, which is basically connected with the transition to a knowledge-intensive economy and labour. The transition to intensive scientific and technological development requires not only a rethinking of approaches in the field of organization of business processes of the organization but also in the field of management, leadership and employee involvement in the processes.

One of the main tools for managing leadership in an organization is detachment and consideration of the interaction of the concept of vertical and horizontal leadership (Pearce 2006). The author notes that in the case where the interaction between team members and the complexity of the task are a significant factor in the process of activity, the type of horizontal leadership is more effective. The use of methods of vertical leadership leads to demotivation of participants in the processes, due to the fact that the productive dialogue and compromise decision-making process is replaced by a directive or arbitral decision from the top. The process of transition from vertical to horizontal leadership consists in maintaining the vertical leader's overall control functions and preserving the direction of development, passing the process of making concrete decisions to the team level, managing the team members promotion process through delegation of leadership authority (see Pearce 2006).

Eisenberg et al. (2016) confirmed that horizontal leadership models are more effective in performing tasks that have a high level of interdependence and complexity and therefore require the exchange of knowledge and interaction within the group. The complementarity of the approaches and the conditions for their joint implementation were considered (Thylefors et al. 2014). In particular, it was found that responsibility within the team for their own results leads to an increase in the efficiency of the activity.

Taking into account the specifics of the research activities, it should be noted that the traditional models developed in the works (Tuckman 1965), where the team goes through several stages of development, including formation, conflict, rationing and functioning and (Hersey and Blanchard 1988), where management styles are associated with the level of personal and professional development of the subordinate and his compliance with the task and includes a directive, mentoring, supporting and delegating leadership styles, do not allow considering deeper levels of interaction between team members and the integration process of their activities. The modern system of research activity involves the use of a contractual approach based on temporary research groups, which determines a high level of turnover of members within the team and leads to a low degree of integration at the initial stage between the team members.

Thus, group dynamics should be taken into account when analysing leadership management in research activities as different team members can enter at various stages of the accomplishment of activities and lead them. The conceptualization of the transition between vertical and horizontal management within the framework of the project approach was developed (Müller et al. 2015) and consists in forming a category of social cognitive space within which the transfer of functions between team members and vertical management is taking place. The concept of social cognitive space includes three elements:

- empowerment: involves the delegation of rights (from a vertical leader) to manage a team within horizontal leadership;
- the right to independent management for horizontal leaders which determines the acceptance of the individual as a leader in the case of effective management, forms competencies for the further development of the leader;
- unified mental models within a team: knowledge of the capabilities and competencies of team members and their potential for horizontal management and leadership.

The different composition of the considered elements leads to the formation of prerequisites for the emergence of horizontal leadership among the team members. This concept has been empirically researched in both Australia and China (see Müller et al. 2016).

2 Literature review

The significance of leadership in project activities, including the research process, is beyond doubt (Clarke 2012a). The concept of balanced leadership based on a five-stage cycle, including nomination, identification of possible horizontal leaders, their choice, the horizontal management process itself and the transition phase (Müller et al. 2018a), is currently actively developing in the scientific literature. The functional component of the concept is that the designated vertical leader temporarily delegates part of the authority to one or several team members and manages the team indirectly through them. This device of organizational connections within the team allows intensifying the processes of knowledge sharing, and cooperation through the decentralization of the research activities processes. Clarke (2012b) indicates that shared leadership is more effective than vertical in relation to the results in projects with greater complexity, greater differentiation for the purposes of the project when the time load during the execution of the project is high. An alternative concept is presented through distributed leadership when the team operates under the ambiguity of the research task (Lindgren and Packendorff 2009; Feng et al. 2017).

Nevertheless, these approaches do not reflect the structure of the relationship between team members who perform the functions of horizontal and vertical leaders. The new direction, designed to explain the internal structure of this relationship, considers balanced leadership as a dynamic of temporal shifts in authority between the project manager and the team member, understood as a sociological phenomenon within the realistic social theory (Archer and Archer 1995). The change of cycles within a balanced leadership occurs in the sequence described in (Müller et al. 2018b):

1. Formation of members of the project/research group. The vertical leader organizes the inclusion in the team members with the necessary competencies and carries out the planning and distribution of responsibilities based on the objectives of the project.
2. Identification of potential horizontal leaders. Within the framework of the stage, the correspondence between the tasks of the project and the capabilities of the team members to the leadership is determined. (Müller et al. 2018c).

3. The recommendation of horizontal leaders. The vertical leader selects temporary horizontal leaders, delegating to them the necessary powers and responsibilities (Yu et al. 2018).
4. Implementation of horizontal management and management of it. The practical implementation of horizontal leadership by team members is being implemented at this stage. Horizontal leadership is managed through a balance of trust and control mechanisms.
5. The reverse transfer of power from the horizontal leader. At this stage, the cycle of leadership change ends, which usually coincides with the end of the project or its system phase, depending on the appropriateness of the cycle can be repeated (see Figure 1).

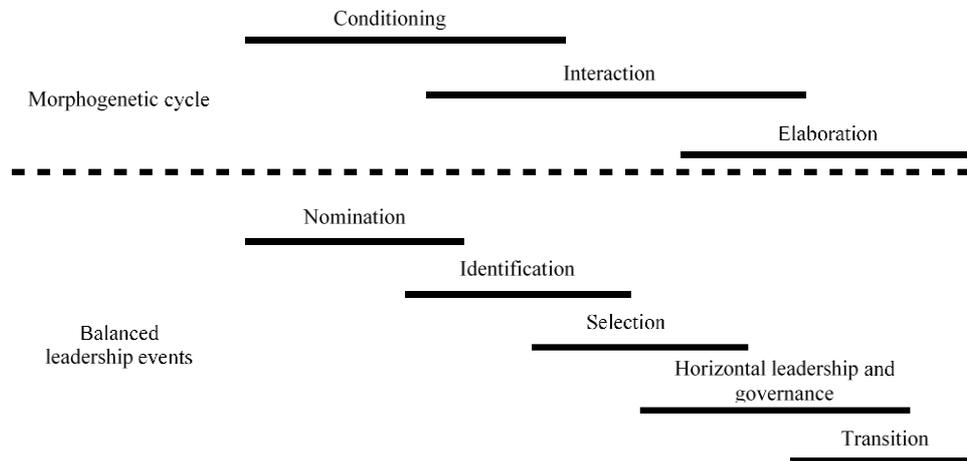


Fig. 1. Comparison of balanced leadership cycles with realistic social theory (morphogenetic cycle)
Source: Müller et al. (2017b)

The contextual factors that determine horizontal leadership and related leadership styles are identified in the work (Pretorius et al. 2017). An empirical study of horizontal leadership factors was implemented in (Pilkienė et al. 2018). The study showed the managerial consequences of horizontal leadership were the formation of direct benefits for the project. In the process of carrying out activities, the main factors associated with finding a balance point between trust and control for managing horizontal leadership are three aspects: 1) the professionalism of a member of the team; 2) personal qualities of a team member; 3) focus and perfection of development programs. Nevertheless, confirmations are found on the need to include horizontal leadership by a vertical leader, while the functional role of horizontal leadership is to distribute areas of responsibility, solve problems and make decisions by team members within a given zone.

Coordination of management within the vertical and horizontal leadership is carried out through a social cognitive space between the team and the manager to identify problems and synchronize the exchange of information (Müller et al. 2015).

The formation of horizontal management mechanisms is realized through two main approaches: trust and control (Bosch-Sijtsema and Postma 2009; Hoetker and Mellewigt 2009). Control, in this paper, is defined as a process that guides and regulates behavior and team members to achieve goals. The definition of control is often associated with levers of its implementation (Simons 1995) or levels (Efferin and Hartono 2015).

Trust as an instrument of horizontal management is a more complex element in an organization that requires the presence of a number of additional criteria, such as a high level of competence of team members and self-organization. In (Mathieu et al. 2000), it was proved that the formation of a single socio-cognitive space has positive implications for the performance of teams.

This paper examines the specifics of the organization of research activities within scientific organizations through the prism of the project approach and leadership within the project team.

3 Research activities and group dynamics: leadership management issues

The main part of process management activities in the previously reviewed literature relates to project management. Despite the fact that the main stages of the evolution and development of the project and research team are identical, it is necessary to consider a number of features associated with the process of research activities.

External factors affecting the management process are identical and include organizational strategy (Morris and Jamieson 2005), organizational structure (Miller and Hobbs 2005), organizational culture (Khalfan

et al. 2007), or (often biased) research productivity (Strielkowski 2017) in organizations as a whole. Internal factors are a much more complex phenomenon in the context of research activities.

The study of the research management process involves not only organizational features but also the very nature of research work. In order to systematize scientific research, several approaches can be distinguished; however, significant differences in the nature of the studied sciences lead to the use of a generalized approach (Rousseau et al. 2018). The most common classification in the conduct of scientific research is its applied or fundamental nature. This approach has been systematized through the development of the Pasteur matrix (Stokes 2005). The quadrant involves the separation of research results related to the study of fundamental and applied results. The names of the quadrants correspond to the names of scientists whose work falls under the appropriate classification. In total there are three types of scientific research:

- Pure fundamental research (Niels Bohr);
- Purely applied research (Thomas Edison);
- Fundamental research based on applied (Louis Pasteur) (see Table 1).

Table 1. The Pasteur Matrix

		Considerations of use?	
		No	Yes
Quest for fundamental understanding	Yes	Pure basic research Bohr	Use-inspired basic research Pasteur
	No	-	Pure applied research Edison

Source: Koshland (2007)

Van Rijnsoever and Hessels (2011) showed that project leaders with a mindset that is relevant to the Pasteur quadrant were the most successful leaders for interdisciplinary work, which mainly includes modern research work (Abramo et al. 2018).

In addition, the “Cha-Cha-Cha” theory developed by Koshland (2007) is of great importance in the context of this study. The theory divides scientific discoveries into three categories: charge, challenge, chance.

The first category involves a clear statement of the problem, to which solutions are not developed. Thus, this scientific discovery consists of identifying obvious patterns that have not been described before. A classic example of the implementation of this category is the discovery and formulation of Newton's theory of gravity.

The second category implies a set of data or observations that need to be explained. Thus, the research task is not formulated at the time of its commencement but is formulated in parallel with the research process. This type of scientific discovery is formed through the creation of the Special Theory of Relativity by Einstein since the idea itself was started because of a number of inconsistencies between Newtonian mechanics and Maxwell's electromagnetic equations.

The third category is associated with the scientific discovery of the "happy occasion", but it should be noted that the researcher's preparedness was as significant as luck. This category includes discoveries that are not the direct purpose of the research but arise in its process. The significance of this category of discoveries grows with the expansion of the role of an interdisciplinary approach to the scientific process.

An analysis of these two classifications gives an idea of the diversification of the nature of the research process, depending on the nature of the results and the initial research data. However, the direct process of research activity remains unrevealed. For the purposes of this article, the research process will be considered within the four stages proposed (Shneider 2009).

The first stage includes an introduction to the subject of research, based on existing information, as well as their experiments and research. At this stage, the main features of the future theory are being developed, which has a number of inaccuracies. Note that the result of the work at this stage relates rather to the Bohr quadrant in the Pasteur matrix, since the application is limited by two factors: the lack of developed application solutions and the ways of their implementation, as well as the degree of coverage of the problem, which reduces the potential in forecasting and modelling.

The second stage consists of the development of basic approaches and methods for analysing a problem or theory developed in the framework of the first stage. At this stage, there is a rethinking of other major scientific disciplines and the use of alternative methods, as well as the addition and rethinking of individual results of the first stage. Applying the Pasteur matrix to this stage, it can be concluded that the second stage corresponds to a certain variant of Pasteur's quadrant when an extension of the applied nature of the research leads to further study of the fundamental topic.

Within the framework of the third stage, the greatest volumes of knowledge are created, and relevant data are obtained. At this stage, the formulated hypothesis must be confirmed or refuted; the results of the research create prerequisites for new research. Thus, a fork is formed during which the research activity either returns to the first stage (if the hypothesis is refuted, the data do not correlate with reality and a fundamental rethinking of the principles underlying the theory is necessary) or goes to the final fourth stage research process.

At the final stage, the systematization and transfer of knowledge take place, in this way new knowledge is incorporated into the existing scientific system. The significance of this stage lies in the fact that systematic knowledge allows facilitating the process of their use in applied research. In addition, the process of communication and dissemination of knowledge has positive results for the development of science in general.

The main characteristics and features of the research process considered in this section allow us to proceed to the analysis of the process of managing it through the formation of socio-cognitive and organizational ties at various stages. The table below presents a summary data of the organizational and internal specifics of research activities in scientific organizations.

Considering the differences in the concepts of vertical and horizontal leadership, it is necessary to understand that these concepts are complementary and are implemented in order to improve the efficiency of managing the team and the research activities in general. Applying the group dynamics approach of the team, developed (Müller et al. 2017a), we can trace the fundamental difference in the essential nature of management between the horizontal and vertical leader.

The motivation of a research team member, in this case, is the awareness of the possibility and necessity of managing and organizing part of the work on the basis of their knowledge, skills and competencies, while the role of the vertical leader is to promote the best prepared and relevant team member on this position. Thus, a three-tier management model is formed, in which the top-level of relations (within the project) is the interaction and coordination of vertical and horizontal leaders (of which there can be more than one, for example, when implementing complex, interdisciplinary projects), organizing the work of their teams, and also the organization of inter-group interaction with preservation of specialization and focus of each of the teams. At the lower level, the horizontal leader interacts, who is a nominated member of the team and provides direct practical guidance to the research process.

The interactions described above represent a conceptual understanding of the organization model for managing a research team, but at the same time, this level of generalization does not allow to form or detail a model sufficient enough to produce any meaningful practical results, which reflects the need to detail this model each of the considered stages, as well as the formation of basic criteria for the stages of nomination, identification and selection of horizontal leaders.

A formalized leadership approach was developed (Müller et al. 2017a; 2017b) based on a global study of the specifics of group dynamics in project teams. This approach identifies five events that correlate with realistic social theory but deepen understanding of the processes of the first stage. Realistic social theory connects the first three stages of the existence of a team, as it connects structural and human expectations with their influence on the ability to achieve goals.

A two-way analysis of the nomination and identification process was conducted as part of the study (Müller et al. 2018b). The study was of a diversified nature in relation to the sphere of activity of the respondents, in connection with which for the purposes of these study additional interviews were conducted in the field of research activities, in particular, those involved in conducting fundamental research. There were 23 interviews with managers and members of research teams. 7 interviews were conducted with research project managers, 16 with members of teams. It is worth noting that the steps of the identification and nomination process coincide with the results of the study (Müller et al. 2018). At the same time, there are a number of fundamental differences, so increasing specialization is a more complex and long-term process than in other companies (Interviews 6, 8, 17). The organizational and technical aspects are less significant in the course of the research process, at the same time academic qualifications, the experience of conducting an expert evaluation of the work performed (Interviews 2, 5, 12, 16). On the other hand, a preliminary assessment of team members can be carried out through the use of the authors' public activity and expert evaluation of their scientific work, which greatly simplifies this process not only by the team leader to assess the competence of a team member as a potential horizontal leader (Interview 1, 7), but also for the team member creates opportunities to take the initiative and express a desire to become a horizontal leader (Interviews 19, 20, 23). The possibility of practical implementation of skills and personal growth of participants depends on a complex system of factors, including

the degree of participation in the study, interaction with other members of the team, access to literature, specialization and diversification of research activity (Interviews 8, 10, 11).

Table 2. The case study data and roles of interviewers

Case no.	Organization type	No. of employees*	No. of interviews	Roles interviewed		
				RPM	SR	AsR
1	University	> 1000	7	2	2	3
2	University	> 750	5	1	1	3
3	Government research centre	100-150	4	1	1	2
4	Consultant company	< 75	3	1	2	-
5	Research university	> 300	4	1	2	1

RPM = Research project manager, SR = Senior researcher, AsR = Assistant researcher

** Note: Number of employees includes only those who participate in research activities*

Source: Own results

Thus, from the point of view of the manager, the stages of nomination and identification in the implementation of research activities include:

1. Preliminary assessment and analysis of scientific networks: the head studies the publishing and research activities and identifies the most qualified members for promotion to the role of horizontal leaders. Significant criteria in fundamental research are the recognition of a team member and his research specialization.
2. Development: is a longer stage in comparison with other project studies, as it is associated with the process of becoming a scientist, acquiring necessary connections, obtaining expert classification, organizational and other competencies. In addition, formal categories such as the presence of a candidate and/or doctoral degree and other awards, titles are a significant condition for the further development of a team member and his promotion to the role of leader.
3. Communication and evaluation: the specifics of the research activities process is the restriction of the use of standard methods for controlling the possession of competencies, which leads to the need to integrate the process of implementing the research activities with evaluating the activities of performers based on the use of expert evaluation tools and the communication process with other team members.

On the part of the performer, additional steps are also highlighted, similar to the study (Müller et al. 2018), but their specificity is different. In addition to a preliminary assessment by team members, the conditions for interaction and competition between team members are highlighted. As already noted, the productivity of interdisciplinary research is related to the effectiveness of communication between team members, in this regard, the communication platform and building work related at the intersection of research areas is fundamental not only to improve team performance but also to develop and nominate team members. In contrast to the general project activities, not only material and career opportunities, but also status motivators, such as scientific recognition, etc., are a reward.

4 The pyramid model: structure, levels and management specifics

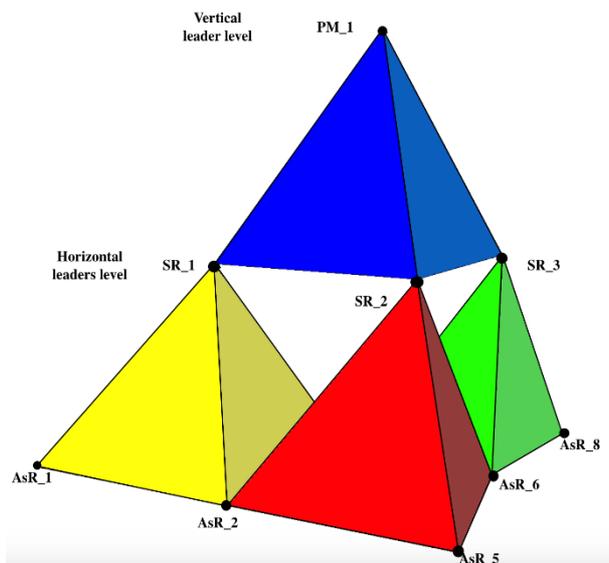
The previous part of the work was devoted to the study of the process of nomination, evaluation and development of horizontal leaders in the organization, at the same time sufficient attention was not paid to their place in the organizational and functional structure in the process of implementation of research activities.

As part of the analysis through a network structure, this research will integrate a number of key aspects of the research activities, such as an interaction between members, the presence of social cognitive zones, leadership and management structure. Existing studies show that centralized networks contribute to increased team productivity (Nguyen-Duc et al. 2015). Over time or depending on the current task, the structures can be dynamic and acquire or lose certain nodes and edges, but the basic configuration of the model remains stable (Rand et al. 2011).

Based on a balanced leadership approach, this paper will consider a pyramidal three-level management structure. It should be noted that this work analyses the scientific teams created for the implementation of a

research project, and not being self-formed based on the similarity of scientific interests. Thus, these teams have a degree of directory management, but at the same time they can apply horizontal management, which causes three levels of the network:

1. The team leader (project manager/vertical leader), appointed by the organization, or initiating the creation of the team, carries out the formation of the team and the evaluation of its members, the distribution of responsibilities, the nomination of horizontal leaders. The key task of a manager is to create a structure of interaction between members of the team and control over the performance of work. Depending on the complexity of the research task, the manager may or may not have the ability to control the execution of the tasks by each team member, which requires the creation of a mechanism for delegating part of the control functions to the level of horizontal leadership.
2. The horizontal leader is a member of the team, possessing the necessary qualifications and competencies for organizing the effective teamwork discussed above. At the level of horizontal leadership, management decisions are made within the framework of the area of responsibility of this socio-cognitive network. Horizontal leaders interact not only with members of their groups and the team leader but also with each other to summarize the results of the work of each of the groups. Thus, horizontal leaders form a social-cognitive network among themselves, similar to the one that exists within the group. The vertical leader enters this network as a coordinator and/or expert. The role of a vertical leader is determined by his management style, personal and professional qualities.
3. A team member undertakes research within his area of responsibility in collaboration with other team members and horizontal leaders. A significant role in choosing the nature of the management of activities (control or trust) is played by the professionalism and personal qualities of a team member. The higher the level of responsibility of a member of a team, the more the horizontal leader has the ability to give priority to trust and not control (see Figure 2).



Note: Colours represent socio-cognitive networks between participants of research process

Fig. 2. Pyramid management model with socio-cognitive networks

Source: Own results

Thus, when considering this structure, two types of socio-cognitive networks arise between the participants of the research team: executive and managerial. The executive network fully implements the initial processes of the research process, such as literature analysis, accumulation and creation of knowledge. The role of the executive network is to create a scientific result within a limited area of responsibility and to reveal the possibilities for applying an interdisciplinary approach. Within the control network, these results are synthesized and disclosed through the reformatting of the executive network system, based on the creation of new tasks already in the framework of an interdisciplinary approach to research. Consequently, the executive (lower) networks of the pyramidal structure are in a dynamic state and vary depending on the stage of the research process.

It should be noted that considered in the communication model connections, within the framework of social cognitive networks, do not exclude certain elements of interaction between team members. These interactions are a significant factor in the efficiency of the teamwork in the early stages of research, as they accelerate the introduction of interdisciplinary elements in the scientific process. The relative independence of groups in the first stages is necessary not only from the point of view of managerial and organizational

convenience, but also from the improvement of the quality of a scientific product, by ensuring a high degree of specialization in the first stages, while maintaining the diversified nature of the research in the final stages.

The considered model of connections in a research team also allows for the maximum exclusion of external influences on the executive, since the horizontal leader is both a member of the team and its organizer, which reduces the likelihood of a conflict of interest between the manager and the performers.

5 Conclusions

Managing the process of research through the institution of horizontal leadership is a complex task. The processes of nominating and evaluating horizontal leaders are complicated not only by the limited functionality of quantitative assessment methods (for example, using bibliometric tools) but also by the lengthy nature of the development process and the need to meet a number of formal requirements. The two-sided specificity of the implementation of these processes in relation to research activities is more pronounced compared to the project, which is a consequence of the relationship of status-related incentives with the result of research activities. In order to integrate the concept of horizontal leadership with the direct process of research activities, a three-tier model of organizational and functional relationships within the scientific team is proposed.

The model allows evaluating and simulate the role of each team member and his connection within the social cognitive network. The use of the institute of horizontal leadership makes it possible to increase the efficiency of research groups at the level of the executive social-cognitive network, as well as to intensify the process of knowledge sharing within the management network. In addition, ensuring effective work within the control network gives an opportunity to quickly transform the executive network of the team and to achieve the most effective work.

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