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ANALYSIS OF METHODS FOR CONSTRUCTING R&D PROJECT TEAMS – RESULTS OF QUANTITATIVE STUDIES

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Purpose: The aim of the article is to analyse and evaluate methods for constructing teams involved in research and development projects and to formulate recommendations regarding their formation.
Design/methodology/approach: The paper utilizes research conducted as part of a master's thesis awarded by IPMA Poland. The research project was based on a mixed-methods approach, combining quantitative and qualitative methods. This combination was chosen to fully understand the phenomenon under study. A sequential explanatory strategy was employed, allowing for the collection of quantitative data, followed by enrichment with qualitative data for a more in-depth interpretation. The adopted model facilitated a comprehensive examination of the subject and enabled an interdisciplinary approach to identified problems.
Findings: The research reveals that some factors, for example team size, do not significantly impact the team's performance assessment. Larger teams report more negative roles. Motivations of participants in R&D projects differ from those in a 2008 study. Currently, career development and networking with other researchers are more important than in the past. Research curiosity is still the most cited motivation for R&D work but by a smaller number of individuals. Teamwork assessment is associated with the number of team issues. The number of roles according to M. Belbin's classification does not influence the team's performance assessment.
Research limitations/implications: The article's limitation lies in the potential omission of advanced dependencies from related management fields – from psychology, sociology, or administration.
Practical implications: The research indicates that key success factors for the practice of managing research and development projects include the appropriate selection of the team leader and effective management of team members' motivation. The number of reported team issues has an inversely proportional relationship with the team's performance assessment. Implementing these practices may contribute to improving the results of R&D teams.
Originality/value: Filling a research gap on the construction of contemporary research and development teams. Discoveries regarding leader selection, researcher motivation, and the impact of various factors on team performance have significant implications for the practice of managing R&D projects. They are addressed to all individuals involved in research and development activities.

Keywords: research and development projects, team construction, research and development, R&D projects.
Category of the paper: research article.

1. Introduction

Research and development projects require the application of highly specific management methods and belong to the category of projects that are both the most challenging and the most significant for the development of organizations and society (Kisielnicki, 2018). A team, however, is defined as a group of individuals with complementary skills, sharing a common goal, value system, and approach for which all members feel responsible (Kossowska, Sołtysińska, 2006).

The selection of team members for a project and subsequently allocating tasks among them is one of the initial tasks falling within the responsibilities of the project manager. Managers recognize the significance of this matter, with over 84% of project managers identifying it as an important aspect, and as much as 94.7% of research project participants considering it a crucial duty (Krawczyk-Bryłka, 2012).

The size of a project team depends on the specificity of the given task, interaction capabilities, but for ensuring effective collaboration, according to M. Pawlak, the number of individuals should range from 4 to 10. This considers the individual characteristics of team members, such as learning ability, intellectual proficiency, and willingness to work collaboratively (Pawlak, 2006).

A much older study aimed at finding the optimal number of individuals in a team that would ensure the satisfaction of individual members with the outcomes of collective work was conducted by J.R. Hackman and N. Vidmar as early as 1970. A team consisting of 2 to 7 people worked on various types of tasks requiring collaboration and effective goal achievement. Each participant answered one of two questions to assess whether the group was too small or too large compared to the task requirements. The results showed that participants did not consider the group too small if it consisted of 7 people. However, as the number of members decreased, they increasingly agreed that the group was too small to effectively perform the task, and they felt uncomfortable in situations with limited resources. On the other hand, in the inversely worded questions, not many people felt that a group consisting of 2 or 3 individuals was too large compared to the assigned task and comfort of work. The optimal number of people in the team in this study was 4.6, suggesting that it is best to form teams consisting of 5 individuals, the closest odd number (Hackman, Vidmar, 1970).

In the book edited by M. Wirkus and A. Lis titled "Managing Research and Development Projects", a study from 2008 conducted by the Information Processing Centre is included. The study focuses on motivating factors for engagement in scientific and development projects

(Wirkus, Lis, 2012). Among the motivating factors identified were the opportunity for international travel, official orders, financial motivation, the chance to meet other scholars, the opportunity to work on a project led by a renowned scientist, the development of a scientific career, the desire to do meaningful work, and research curiosity. Individually, research curiosity and the desire to do meaningful work were considered the most important sources of motivation (Krawczyk-Bryłka, 2012). The two factors mentioned, research curiosity and the desire to do meaningful work, were indicated by 100% of the surveyed individuals at that time.

In the cited study, career development in the scientific field was also considered a significant issue, planned in 60% of the projects. For 70% of the participants, financial motivation was important, while approximately 25% of participants observed a discrepancy between individual interests, team interests, and the overall project. Despite some discrepancies, 95% of research team members were satisfied with their participation in the project (Krawczyk-Bryłka, 2012).

In the study conducted in 2008 by the Information Processing Centre, research and development teams were asked to identify problems within their teams. According to 26% of the participants, their groups lacked clear cooperation principles. Only 25% of respondents identified the entire team as responsible for carrying out individual project stages, while 52% indicated a lack of dedicated tasks for specific project participants (Wirkus, Lis, 2012).

M. Belbin developed a theory of team roles, indicating that the roles individuals play have an impact on the quality and effectiveness of teamwork. In his theory, he identified nine team roles that occur in organizations:

- Task-oriented roles include Shaper/Implementer/Completer Finisher;
- People-oriented roles include Coordinator/Team Worker/Resource Investigator;
- Intellectual roles include Plant/Monitor Evaluator/Specialist (Belbin Polska, 2023).

The studies conducted in 1995 and 1996, along with a systematic evaluation of the Belbin Model in 2001, questioned the credibility of this model. Statistical analyses indicated that the model does not allow for accurate predictions of reality, and factor analysis challenged the structure based on four pairs of roles. While examining theoretical validity, it was found that the model exhibits some correlation with other measures assessing the same traits, suggesting a certain convergent validity. However, there is an emphasis on the lack of evidence for the existence of differential validity, i.e., independence from traits that should not be related to team roles.

Additionally, a significant issue is the overlap in the definitions of certain roles and imprecise role descriptions, leading to the reparameterization of roles and making their clear definition more challenging. Therefore, despite the model's simplicity and popularity, its credibility has been seriously questioned based on the conducted research and analyses (hrpolska, 2015).

Various methods for building project teams are available from different sources, in addition to the mentioned Belbin Team Role Theory (Belbin Polska, 2023). These include Stochastic Optimization of Belbin's Team Roles (Twardochleb, 2014), DiSC D3 Team Map (Effectiveness, 2023), Sociometric Techniques (Lucius, 1996), Taguchi Parameter Design Approach (Tsai, Moskowitz, Lee, 2003), Rough Set Theory (Omar, Syed-Abdullah, Mohd Hussin, 2011), S.L. McShane and M.A. Von Glinow's Team Role Division (McShane, Von Glinow, 2017), Negative Team Roles by M. Taraszkiewicz, K.F. Nalepa (Taraszkiewicz, Nalepa, 2007), Extended DISC® (DiSC Polska, 2020), Six Professional Personality Types (Lencioni, 2023), Utilization of Individual and Team Performances (Feng, Jiang, Fan, Fu, 2010), Five Dysfunctions of a Team Model (Lencioni, 2002), MBTI in Project Team Building (Kopczewski, Szwarc, 2009), Competency Models (Pauli, 2007), FRIS® - Flexible Resources Integration System (FRIS®, 2023), Gallup's Strengths-Based Talents - Talent Dynamics (Drążkiewicz, 2022). These methods offer diverse approaches to team construction, each with its unique principles and applications.

It is worth examining the development of small groups to distinguish various typical phases that occur during the formation and evolution of each group. One of the most popular models describing these phases is the B. Tuckman model, which is frequently cited in literature and encountered during managerial training. However, there are other models, such as those developed by D. Kezsbom and K. Edward, that describe a model like B. Tuckman's concept. Undoubtedly, the B. Tuckman model is illustrative and aids in understanding the processes that occur during group formation. It is also applied to describe the team-building process, considering the distinctions between the concepts of "group" and "team" (Pawlak, 2006). Meanwhile, according to the B. Tuckman model, in the development of a group, certain characteristic and non-overlapping phases can always be observed, occurring in varying intensities and forms.

Critics of the B. Tuckman model point out that he labelled his model as a hypothesis and noted that this phenomenon was most visible in therapeutic groups. They emphasize that for a hypothesis to become a theory, it must be proven. At the same time, a significant majority of critics agree on one crucial aspect - all five group phases can occur in any environment, but they differ in intensity, sequence, duration, and sometimes some phases simply do not take place. They note that in an ideal corporation where work norms are clear, and everyone accepts them, a new group may not need to create these rules from scratch, thereby skipping one stage of the B. Tuckman process. However, this model originated in a different era with a different context. Critics also believe that a significant flaw in the discussed model is the definition of conflicts because B. Tuckman assumed that all conflicts occur simultaneously, while scientists identify several different sources of conflict in a team, such as: misunderstanding of goals, conflicting interests, the need for independence from the group, disagreement on group structure, and interpersonal conflicts. These conflicts arise at various moments in the life of a group and interplay with each other (Czahajda, 2019).

In the literature, there is a recommendation that the articulated goal of a team should result from common agreements, enhancing its acceptance and providing a sense of interdependence and shared responsibility for achieving specific and ultimate outcomes of work (Krawczyk-Bryłka, 2012).

It is worth noting that, in addition to the above information regarding the general construction of teams, the literature lacks detailed information on the formation of research and development teams. Available sources focus on the formation of teams for other types of projects or are general, not considering the specificity of these kinds of projects. Nevertheless, the thematic aspects of research and development activities are often discussed in a valuable manner.

The aim of the scientific article was an attempt to fill the mentioned gap in scientific knowledge regarding the construction of teams involved in research and development projects.

2. Materials and methods

As part of the diploma thesis, mixed methods research was conducted, utilizing both quantitative and qualitative approaches. These studies enabled a holistic understanding of the phenomena under investigation and yielded comprehensive results. A sequential explanatory strategy was chosen, combining the analysis of quantitative and qualitative data to facilitate a more in-depth interpretation of the findings. The selected research methods included a diagnostic survey and a case study. The diagnostic survey employed surveying techniques, while the case study was conducted based on interviews.

The quantitative study, based on a survey, aimed to generalize data from a sample of 51 research and development groups in Poland in the year 2023. The population of respondents consisted of participants in research and development projects. The sample selection procedure was one-stage, with 9% of the individuals who received the survey responding. Data were collected using the "Google Forms" tool and processed using Microsoft Excel. The data collection procedure included pilot tests and sending surveys to the mailboxes of individuals associated with research and development projects. Email messages were sent in waves, with each wave consisting of approximately 100 recipients. Between waves, there was a period of 2 to 5 days, and no differences were observed in responses between the waves. The applied scale ranged from integers 1 to 10, where 1 indicated low and 10 high.

Within the qualitative study, a case study strategy was employed through conducting interviews with six representatives from different research and development projects. This research strategy allows for an in-depth understanding of a specific case, expanding on the most interesting and surprising results from quantitative research. The case study method is

applicable in social sciences, although the results may not be generalizable to the entire population.

Careful sampling procedures and interview locations were applied, deliberately selecting representatives from various areas where research and development projects are conducted. All individuals were informed about the purpose of the study, measures were taken to protect anonymity, and interview procedures were structured. Data analysis was conducted concurrently with data collection, following J. W. Creswell's model, incorporating data coding and source triangulation to ensure the credibility of the results (Creswell, 2013).

3. Results

In the quantitative study[1] conducted through a survey, a total of 51 responses were obtained. The study encompassed all generations actively involved in research and development projects. The age range was broad and balanced (Figure 1). The youngest participant in the study was 22 years old, while the oldest was 78. Analysing the chart, one can observe the presence of both female and male representatives in each age group. The percentage of women in the study was 49%, and for men, it was 51%. The mentioned sample aimed to eliminate results that could be influenced by generational or gender differences.

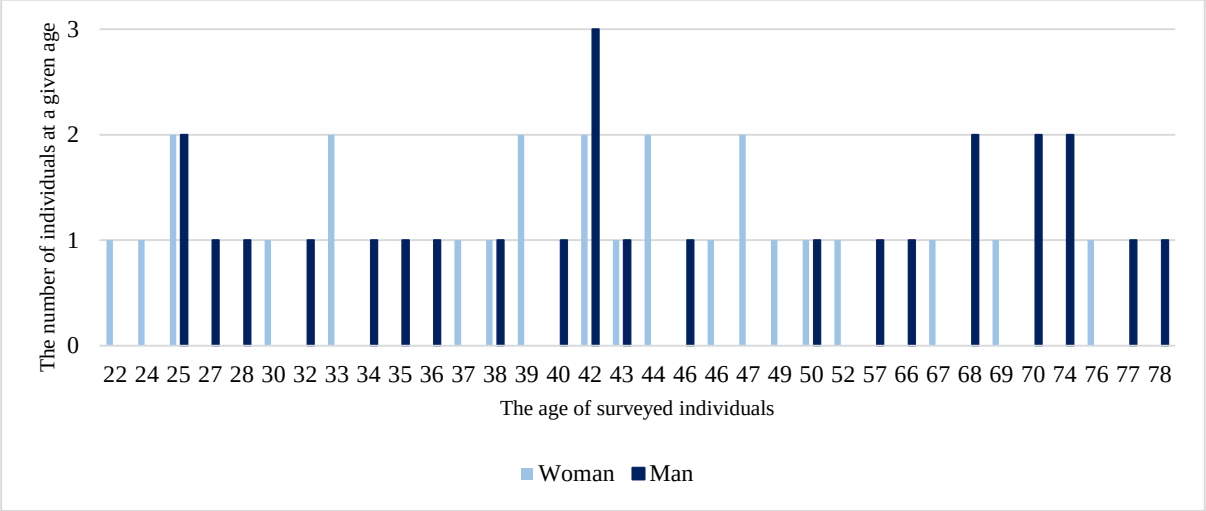

Figure 1. Age and Gender of Respondents.

Source: Own research.

It was examined whether all respondents come from teams based on the definition by M. Kossowska and I. Sołtysińska, stating that a group is a team when it has a common goal, values, and a sense of responsibility (Kossowska, Sołtysińska, 2006).

[1] This article contains the results of quantitative research only.

As many as 86% of the respondents came from teams, 8% found the question challenging or did not know the answer to the question (Figure 2). Only 6% of the participants denied that their group had a common goal, values, and a sense of responsibility - surveys with this response were excluded from the analysis focused on studying teams.

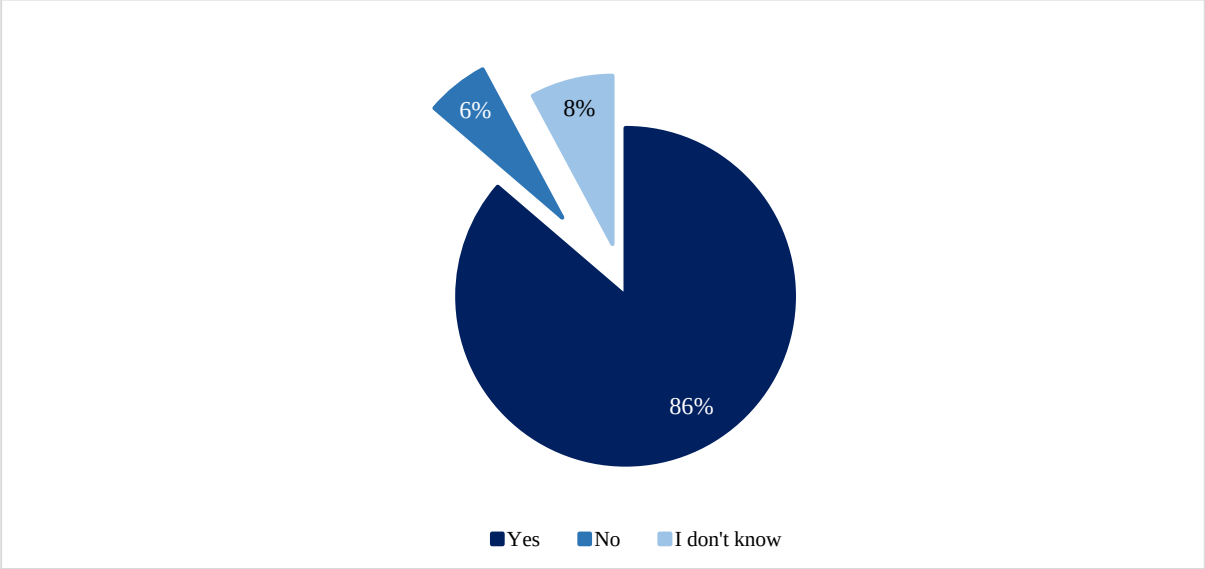

Figure 2. Having a common goal, values, and a sense of responsibility among the surveyed groups.

Source: Own research.

The study also includes diverse data regarding the size of the groups (Figure 3). The research covers small, medium, and large teams. It can be observed that the majority of groups have a small number of members. Groups with up to seven people account for 63% of all surveyed. Eight or more members were reported by 37% of groups.

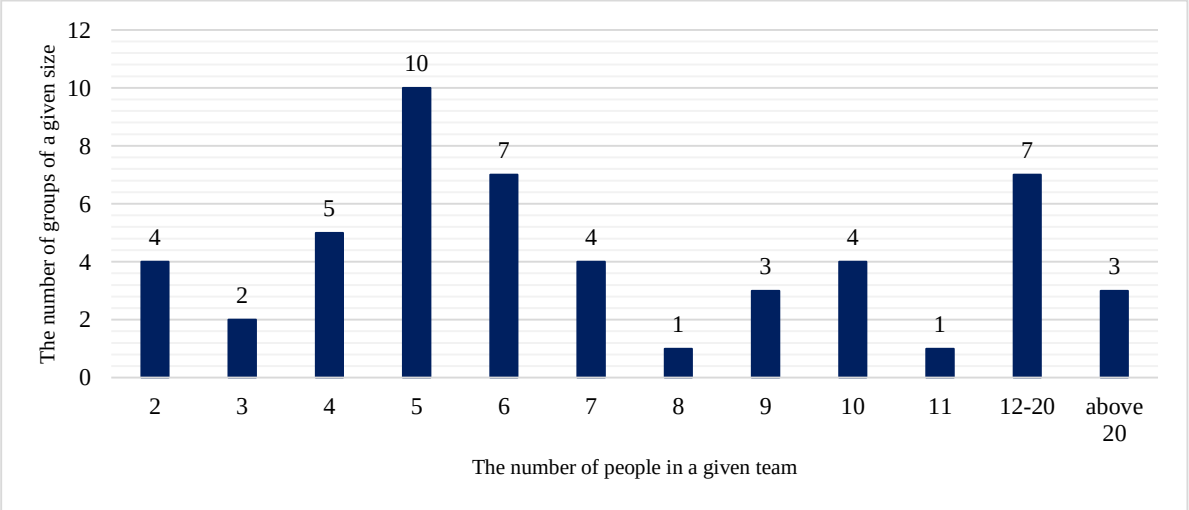

Figure 3. Size of the surveyed groups.

Source: Own research.

Each type of organization in which R&D projects are conducted had its representation in the study. (Figure 4) The highest number of projects were conducted within academic research (43%) and research and development institutions (33%).

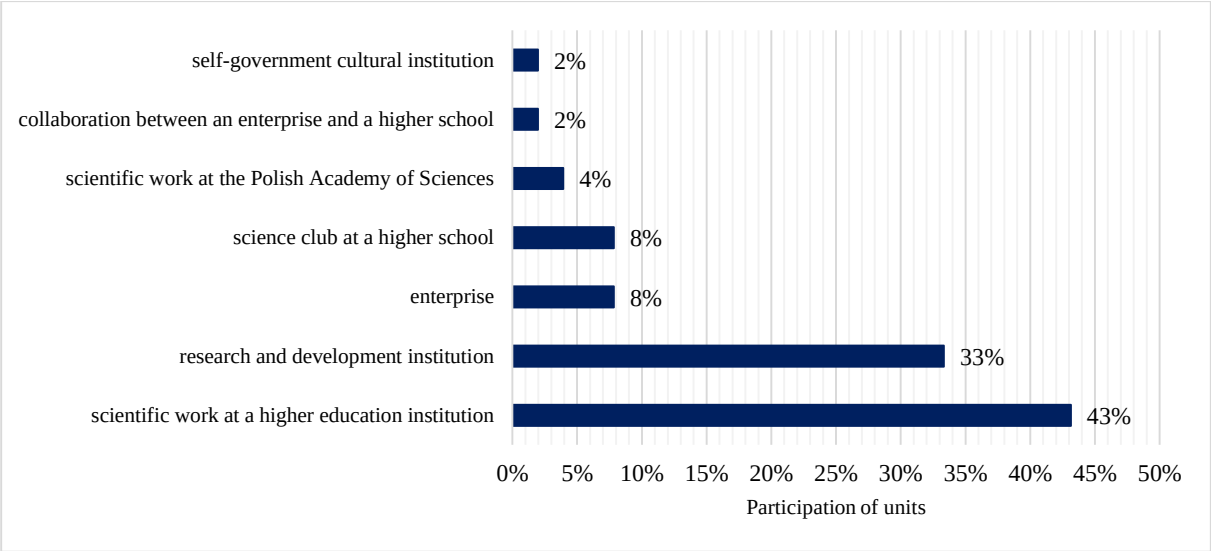

Figure 4. Units within which R&D projects were/are conducted.

Source: Own research.

Multiple times it was indicated that the project manager was also the initiator of the project (78%). (Figure 5) This is a factor that influenced the choice of the project manager. Substantive knowledge in the project area was also important in selecting the project manager (57%). In several cases, it was mentioned that the project manager had to possess this knowledge. Sometimes the selection of the project manager depended on managerial predispositions (18%).

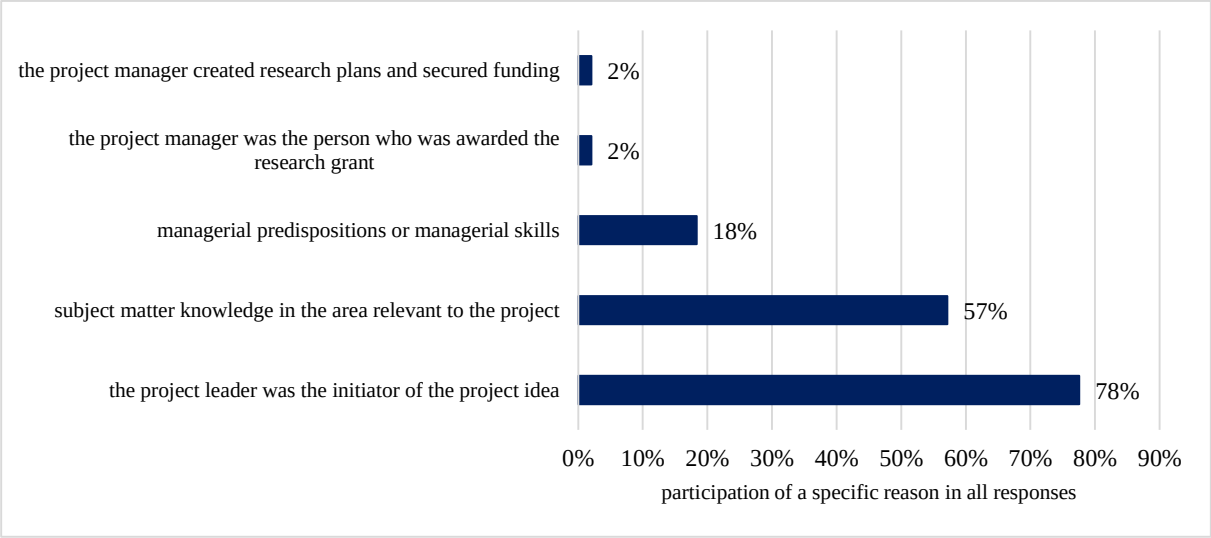

Figure 5. Reasons for choosing the team leader.

Source: Own research.

An analysis of simultaneous reasons for choosing the project manager was also applied (Figure 6). The most common combination is substantive knowledge in the area the project pertains to and being the initiator of the project. However, during this analysis, the project manager who was the initiator of the project as the sole reason still gains the highest percentage share.

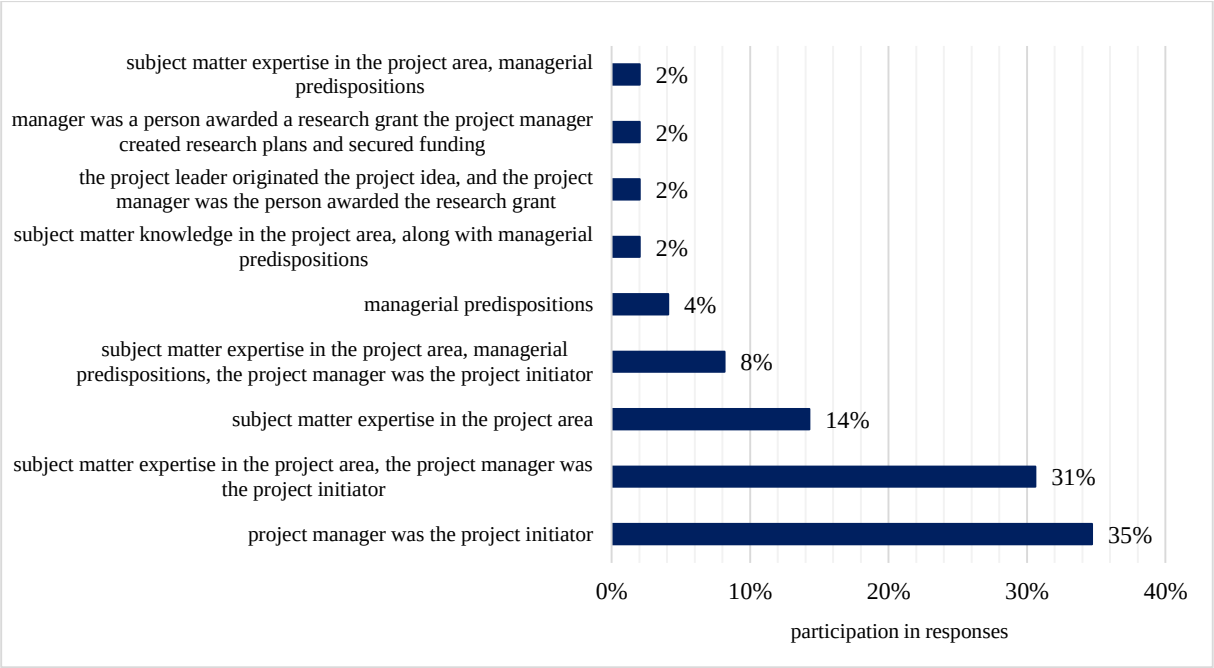

Figure 6. Comparison of the indicated reasons for choosing the team leader.

Source: Own research.

The study involved individuals serving various roles within the project team. Team leaders constituted 69%, team members 25%, while informal team leaders and subject matter experts accounted for 3% each.

Ratings given to the leaders of the surveyed groups were average, high, and very high. The most awarded grade (on a scale from 1 to 10) was 8 (in 31%) and 7 (27%). The maximum rating was obtained by 16% of team leaders.

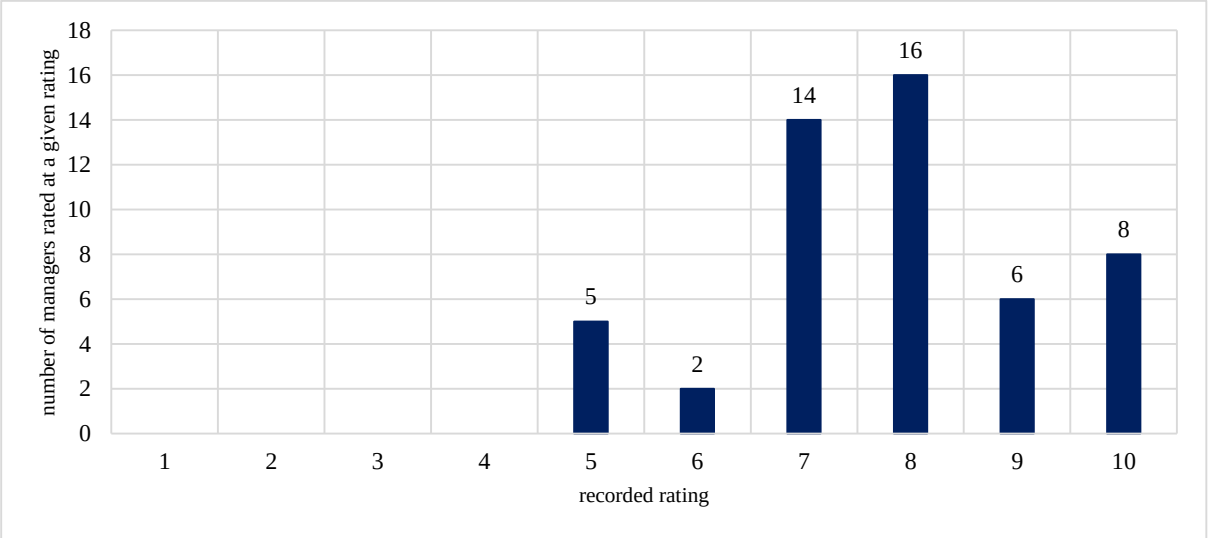

Figure 7. The evaluation of the work of the leaders of the surveyed groups.

Source: Own research.

The evaluation of the team's work ranges from 3 to 10, like the evaluation of the leader, which fluctuates between 5 and 10 (Figure 8). Just like in the case of project team leaders, the most frequently awarded grade was 8 (in 42% of cases). Other popular grades were 9 (in 22%) and 10 (in 17%). The calculations did not include groups that did not have a common goal, values, and a sense of responsibility because, according to the definition, they do not qualify as teams. These types of groups received ratings: 3, 4, 8. A grade of 3 was the lowest among the assigned ratings.

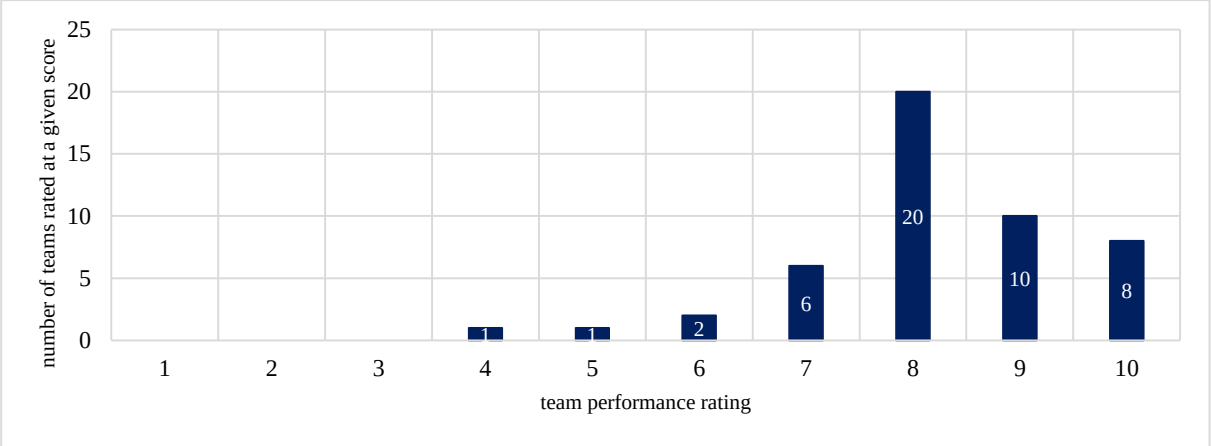

Figure 8. The evaluation of the work of the surveyed teams.

Source: Own research.

The results indicated that there is no clear rule regarding the person entrusted with the selection of team members (Figure 9). Responsibility for team member selection is often assigned to the project manager (46%), but also to the project originator or a group of project originators. In some cases, the team was also given influence over the selection of some individuals.

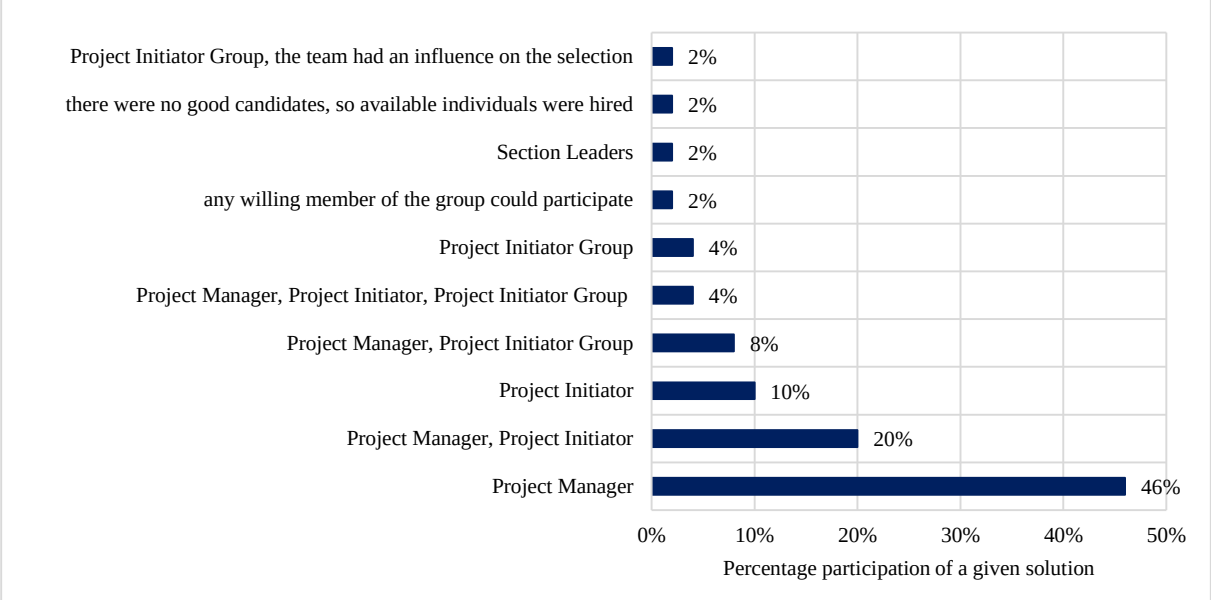

Figure 9. Individuals responsible for selecting team members.

Source: Own research.

Exactly 74.5% of the surveyed individuals are unfamiliar with methods for formulating project teams. Only 25.5% of those operating within research and development teams have knowledge about methods for forming project teams.

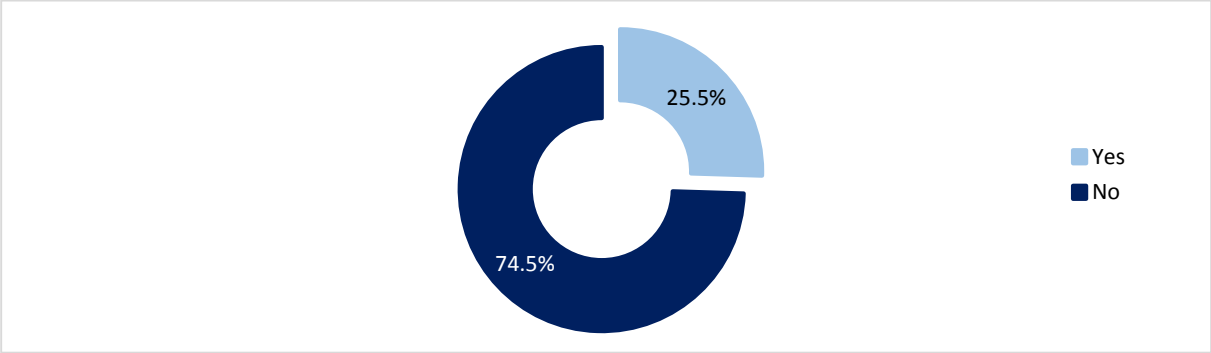

Figure 10. Familiarity with methods for formulating project teams among surveyed individuals.
Source: Own research.

As part of the master's thesis research, an investigation was conducted to determine whether the factors that motivated researchers in research and development projects in 2008 have a correlation with research and development projects in 2023. Additionally, respondents were given the opportunity to identify other motivating factors in the survey. The results of the study indicate that only a portion of the factors align with those published in 2008.

In the older study, factors such as research curiosity and the desire to do meaningful things were indicated by almost 100% of the respondents. In the current study, we can observe that research curiosity is indicated at a level of 84%, and the desire to do meaningful things is at 47% (Figure 11). Interestingly, about 9 percentage points more respondents in the current study indicated a motivation for career development compared to the earlier study. Previously, approximately 40% of respondents indicated the opportunity to work on a project led by a renowned scientist; in the current study, only 8% did so. The opportunity to meet other scholars was important for about 50% of respondents in 2008, and in the current study, it was significant for 22%. Financial motivation was indicated by approximately 45% of respondents in the earlier study, and in the current study, a similar value was observed – 43%.

In 2008, as motivating factors for engaging in research and development projects, less than 20% of respondents declared official orders and the opportunity for international travel. In 2023, official orders were significant for only 4% of individuals, while the possibility of international travel was more popular, with 24% indicating its importance. Respondents also pointed out other factors, including the desire and ambition to conduct scientific research (2%) and the preparation of a doctoral thesis (2%).

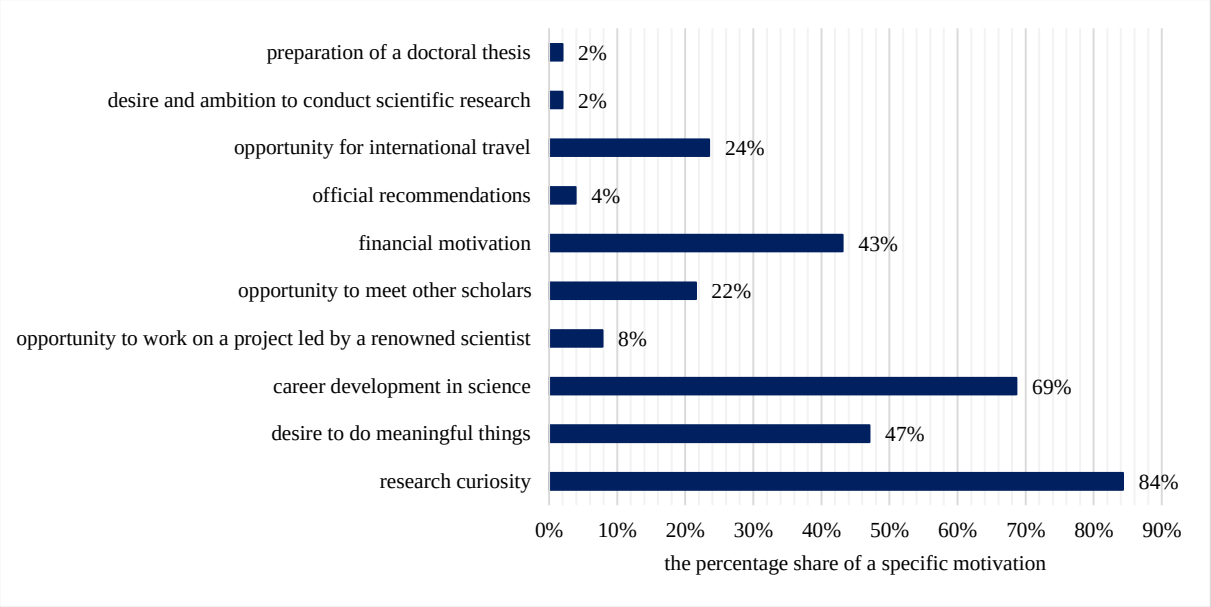

Figure 11. The motivations of respondents to participate in research and development projects.

Source: Own research.

The most frequently reported roles in research and development teams were Specialist (76%), Coordinator (70%), and Creator (68%). The least common role was Implementer (26%) (Figure 12). Only in 8% of teams were all roles noted. The average number of roles in teams was 4.57, with a median of 4.

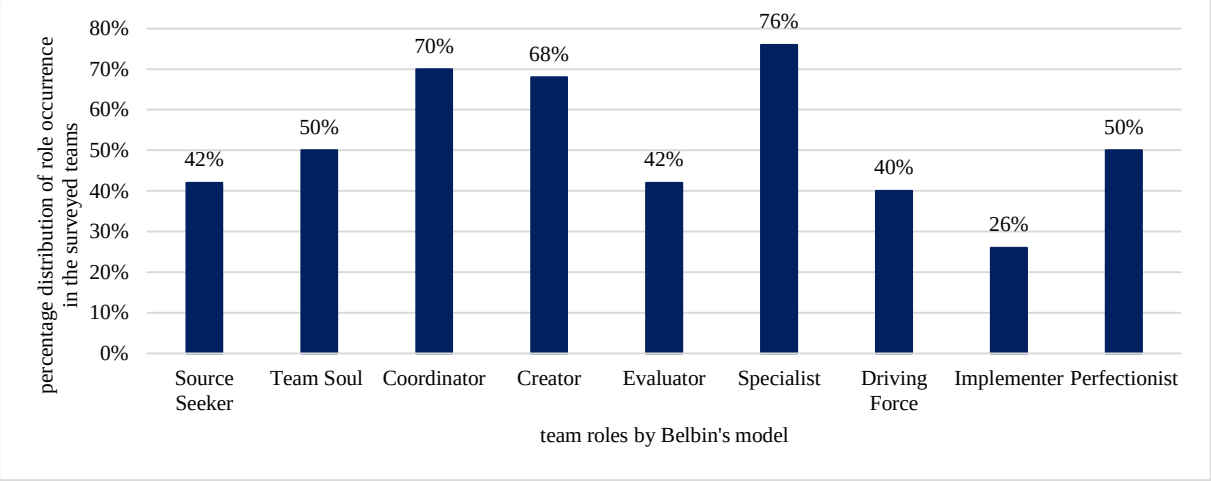

Figure 12. The roles identified by M. Belbin present in the surveyed teams.

Source: Own research.

Research and development teams vary in terms of the percentage of women's participation (Figure 13). The majority of teams (34%) have a percentage of women in the range of 41-59%. As the percentage of women decreases or increases, the number of teams with such participation decreases. It can be observed that values on the right side of the chart are a few percentage points lower than those on the left side with a higher percentage of women's participation.

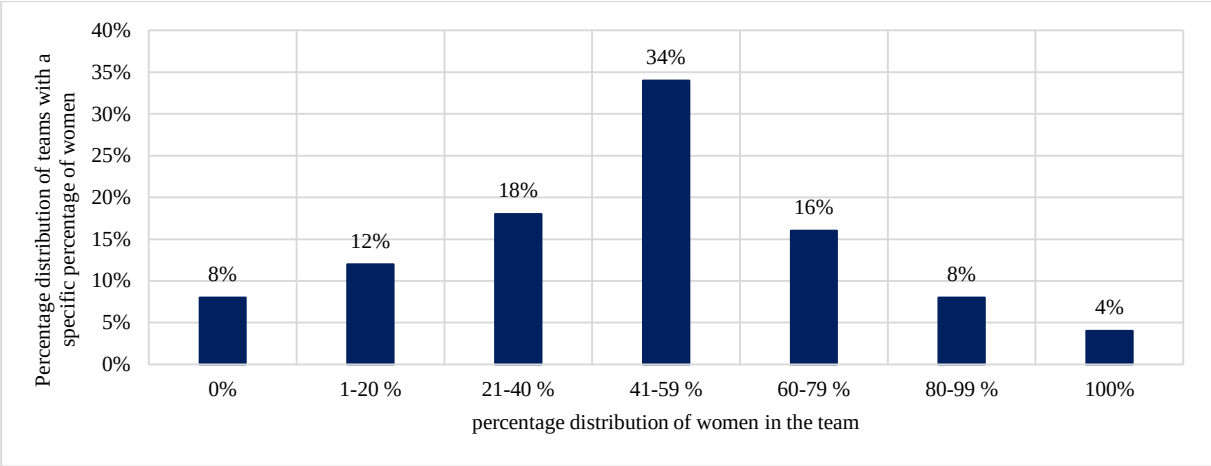

Figure 13. Percentage of women's participation in the surveyed teams.

Source: Own research.

From the research conducted as part of the master's thesis, different results were recorded than those previously published in 2008. Only 8% of participants did not have clear collaboration rules (compared to 26% because of the earlier study). The most significant problem faced by over half of the teams (55%) was administrative and economic issues. Insufficient sense of responsibility for the project by members was also a frequently reported problem (35%). Only 20% of teams declared no problems.

Individuals participating in research and development projects within a scientific circle at a higher education institution face an average of three problems. Those involved in similar projects as part of academic work at a higher education institution and research and development institutions reported about half fewer problems (1.59), and the average for scientific work at the Polish Academy of Sciences was even lower (1.50). The average for businesses is much lower at 0.5.

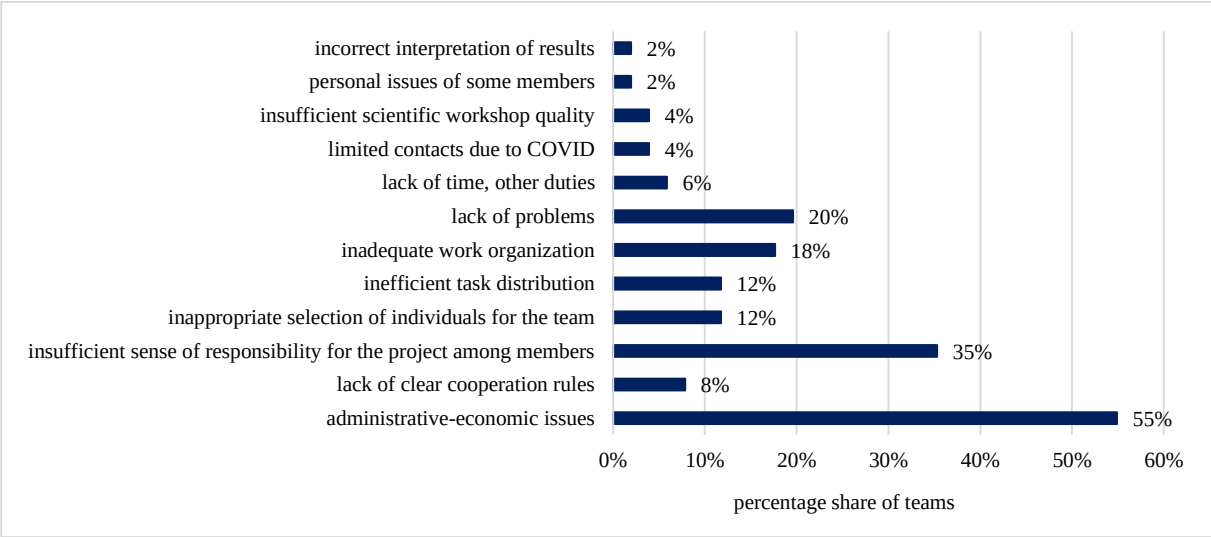

Figure 14. The most significant problems reported by the surveyed project teams.

Source: Own research.

As many as 63% of the surveyed teams reported the occurrence of negative roles within the team (Figure 15). Only 35% declared the absence of such roles. Two percent of respondents found it difficult to respond to this question. The most reported negative roles in the surveyed teams were Passive (37%), Victim (29%), Blocker (20%). The average number of negative roles within a team was 1.29, with a median of 1.

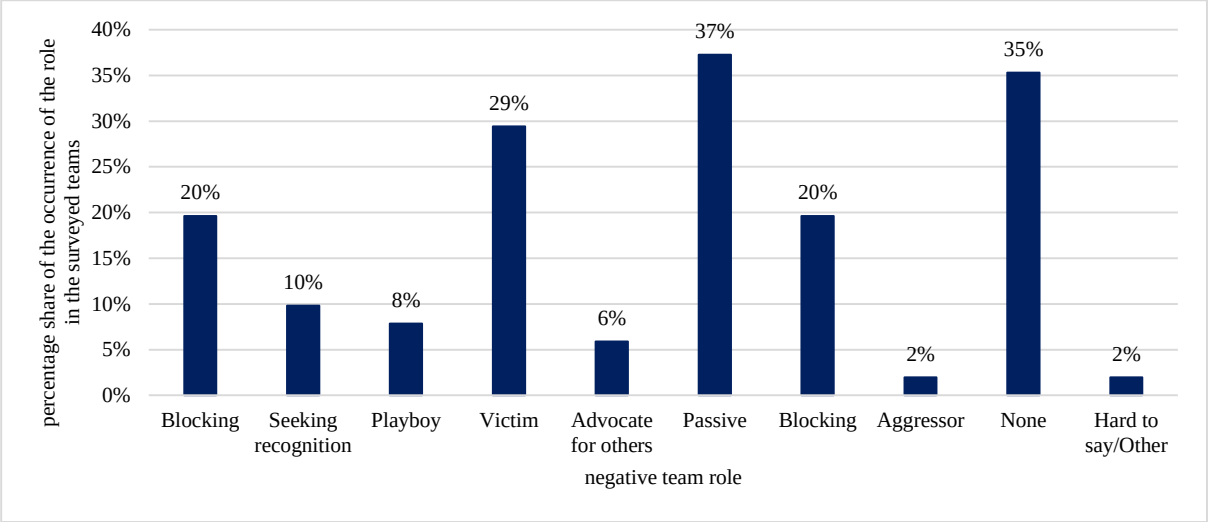

Figure 15. Negative roles observed in the surveyed teams.

Source: Own research.

Ten respondents reported that their group is at more than one stage simultaneously. One respondent indicated three stages, while the remaining nine mentioned two stages. The most frequently mentioned stage was the execution stage.

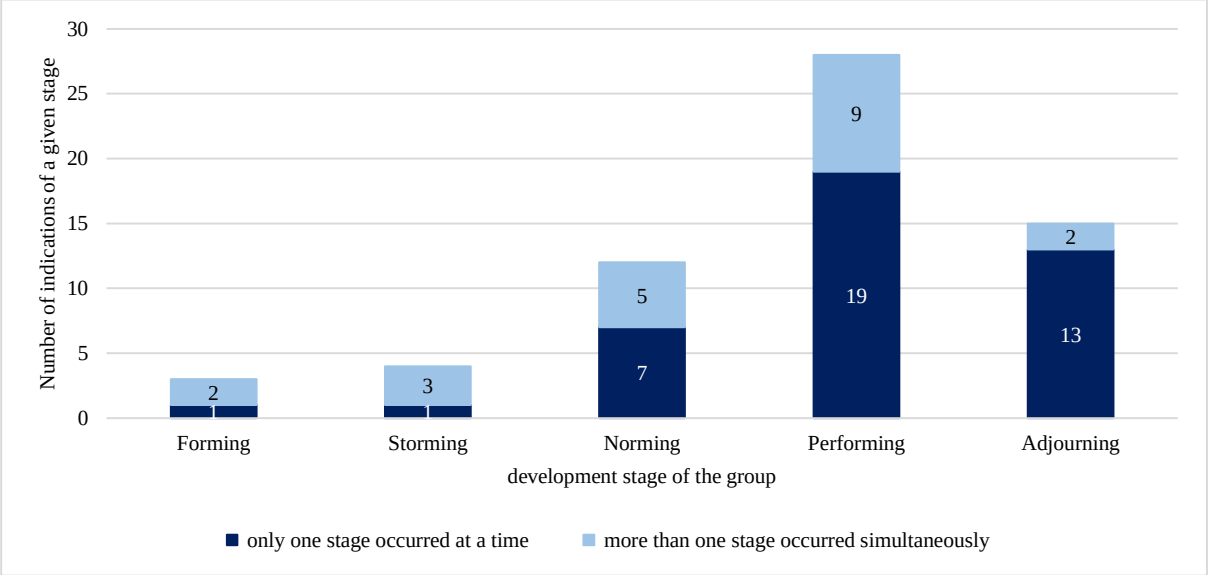

Figure 16. Stages of development of the investigated teams.

Source: Own research.

It can be observed that in 53% of groups (27), an increase in engagement was noticed among individuals participating in setting the goal during its implementation (Figure 17). No such effect was observed in 6 teams, constituting 35%.

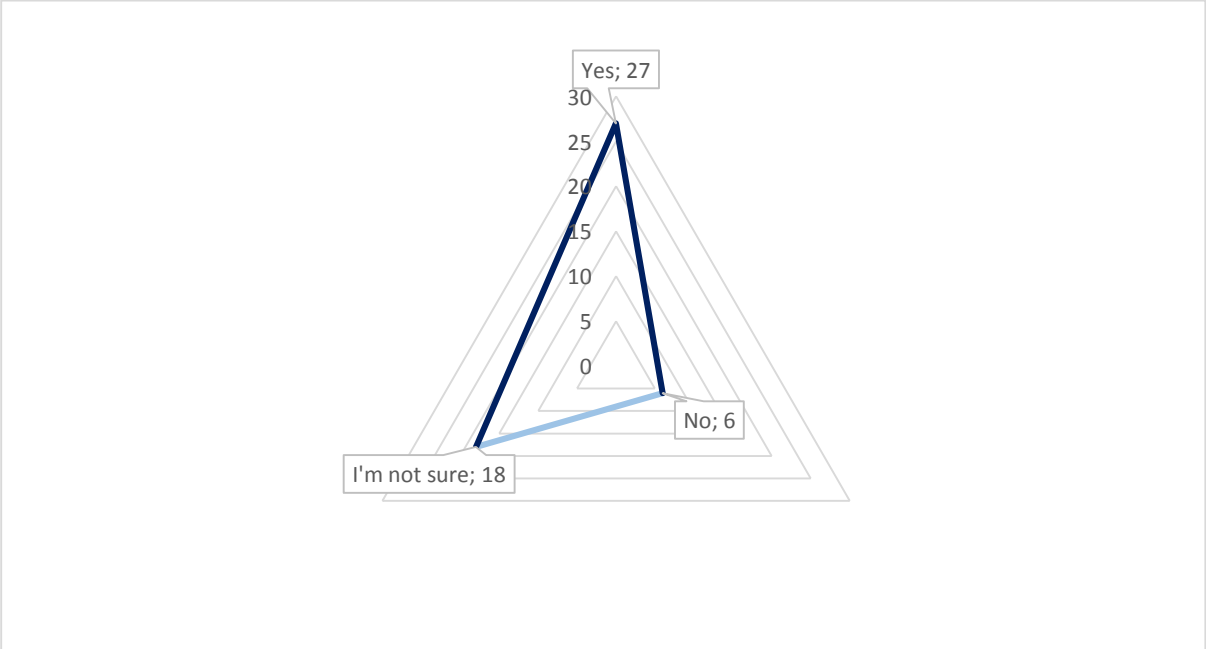

Figure 17. Engagement in the achievement of the goal by individuals involved in its definition.
Source: Own research.

The obtained data were converted into values for which it is possible to calculate the Pearson correlation coefficient (r-Pearson). Based on declarations regarding the positive roles present in the team, the number of these roles was calculated for each survey separately. A similar method was applied to negative roles. The counting of responses was also carried out for the indicated problems that the team faced and the number of stages it was at.

Respondents who declared that their group had a common goal, values, and a sense of responsibility (marked "yes") received a score of 1 for this response, while those who marked "no" received 0. Participants indicated percentage ranges for the proportion of women in the team and the percentage of people focusing on tasks or relationships. To calculate the correlation coefficient, the ranges were converted into the minimum and maximum values of each range.

In the case of the selection of individuals by the leader or initiator, previous analysis led to conclusions suggesting a positive and strong impact on the team's performance. To verify these findings in the case of selection by the mentioned individuals, a score of 1 was assigned, and the rest were marked as 0. Other variables subjected to correlation calculations were collected as numerical variables (Table 1).

Table 1.
The values of the Pearson correlation coefficient (r) for the variable data

	Team performance evaluation	Assessment of the team leader's performance	Familiarity with methods of team formulation	The number of Belbin roles in the team	Common goal, values, and a sense of responsibility	The percentage of women in the team (min)	The percentage of women in the team (max)	The percentage of team focused on tasks (min)	The percentage of team focused on tasks (max)	The selection for the team by the manager or the originator	The number of reported issues	The number of negative roles within the team	The number of stages at which the team operates	The age of the surveyed individual
Team performance evaluation	1													
Assessment of the team leader's performance	**0.45**	1												
Familiarity with methods of team formulation	-0.17	-0.04	1											
The number of Belbin roles in the team	**0.06**	0.14	0.13	1										
Common goal, values, and a sense of responsibility	**0.48**	0.26	-0.24	0.07	1									
The percentage of women in the team (min)	-0.09	-0.09	-0.07	-0.09	-0.03	1								
The percentage of women in the team (max)	-0.10	-0.12	-0.02	-0.08	-0.05	-	1							
The percentage of team focused on tasks (min)	0.20	0.12	-0.19	0.00	0.17	-0.08	-0.12	1						
The percentage of team focused on tasks (max)	0.26	0.20	-0.12	0.03	0.17	-0.08	-0.11	-	1					
The selection for the team by the manager or the originator	0.05	0.01	-0.33	-0.25	0.24	-0.03	-0.05	0.32	0.13	1				
The number of reported issues	**-0.43**	-0.34	0.13	-0.07	-0.09	0.05	0.07	-0.10	-0.03	-0.16	1			
The number of negative roles within the team	-0.08	-0.08	0.34	0.29	-0.20	-0.05	-0.10	0.00	-0.03	-0.04	0.03	1		
The number of stages at which the team operates	-0.25	0.01	0.22	0.06	**-0.43**	0.02	0.05	-0.03	0.00	-0.18	-0.02	-0.02	1	
The age of the surveyed individual	0.04	-0.18	-0.17	-0.24	0.18	-0.06	-0.01	-0.05	-0.17	0.25	-0.14	-0.32	-0.28	1

Source: Own research.

The highest value of the Pearson correlation coefficient (0.48), indicating a moderate degree of dependence, is observed for the relationship between having a common goal, values, and a sense of responsibility and the team's performance assessment (Table 1). The team leader's performance evaluation also moderately correlates with the team's performance assessment (0.45). Conversely, the number of reported issues is inversely proportional to the team's performance assessment (-0.43) and assumes a moderate value. There is a moderate and inversely proportional correlation between having a common goal, values, and a sense of responsibility, and the number of stages at which the team operates (-0.43). A very low correlation coefficient is noted between the number of positive roles in the team (according to M. Belbin's classification) and the team's performance assessment (0.06).

4. Discussion

The participation of women and men in the study was balanced, and no discrepancies arising from the gender proportionality of respondents should occur.

Analysing the data, it can be observed that familiarity with methods of formulating project teams has a minimal impact on the team's performance assessment. Some cases show that team members with knowledge receive higher ratings, but this is not consistent. There are also instances where team members without such competence receive high ratings. Therefore, it cannot be conclusively stated that familiarity with methods of formulating project teams has a strong positive impact on performance assessment. Other factors, such as skills, commitment, or team efficiency, may have greater significance for assessment.

Familiarity with team-building methods is not dependent on the individual from whom the surveyed person originates. No correlation was observed between the motivations guiding an individual to participate in a research and development project and the unit of origin; responses were highly diverse.

Based on the data, there seems to be no relationship between the project's location and the size of the team. The team's size does not significantly differ based on the project type and unit; all have both small and large teams.

A considerable number of groups with five members can also be noticed. This may relate to the concept mentioned in the introduction, stating the optimal number of people in a team, calculated to be 4.6, suggesting that it is convenient to form teams consisting of five participants, which is the closest odd number (Hackman, Vidmar, 1970).

It cannot be conclusively stated whether the group size directly influenced its performance assessment. The data suggest that the team's performance assessment generally remains stable and independent of the number of team members. For instance, groups of varying sizes (from 4 to over 20 people) received similar performance ratings, such as 8, 9, or 10.

Analysing the data reveals a relationship between team size and the number of roles. Larger teams (10-11, 12-20, above 20) tend to exhibit a higher number of negative roles, such as 3, 2, or 4. In smaller teams (4, 5, 6), the number of negative roles is diverse but more often amounts to 0 or 1.

Considering the relationship between team size and the number of issues, dependencies can also be observed. Larger teams (10-11, 12-20, above 20) tend to report a greater number of issues - 2, 3, 4, or 5. In smaller teams (with 4, 5, or 6 members), the number of issues is varied but more frequently takes values of 0, 1, or 2.

An interesting aspect is the reason for choosing the team leader in research and development projects and whether it differs depending on the executing unit. The results indicate that substantive knowledge in the area relevant to the project is essential to become a project leader within academic work at a higher education institution, scientific work at the Polish Academy of Sciences (PAN), or a research and development institution.

A notable trend is that the project originator often becomes the project leader, especially in cases of collaboration between a company and a higher education institution or a research and development institution. No other dependencies between the reason for choosing the project leader and the type of unit were detected. Similarly, in the selection of the person responsible

for selecting members for project implementation, it is not significantly dependent on the executing unit.

A study conducted among research teams in 2008 showed that usually (in 86% of cases), the choice of the project leader resulted from substantive knowledge in the area to which the project pertained (Krawczyk-Bryłka, 2012). At that time, project leaders were individuals who originated the idea in 73% of cases and were typically researchers with no prior project management experience. It can be noted that over the years, the reasons for choosing a team leader have changed.

Analysing the data reveals a correlation between the team's performance assessment and the basis for selecting the team leader. The results suggest that the team's performance assessment is higher when both of the following conditions are met:

- The team leader has substantive knowledge in the area to which the project pertains.
- The team leader was the originator of the project.

When these two factors are present, the team's performance assessment is 8 or higher. However, it was not recorded how the team's performance assessment is attributed to individual factors and is also associated with the team leader. Therefore, it cannot be conclusively stated what impact each of these factors has on the team's performance assessment. It should be noted that the team's performance assessment may also be based on other factors beyond those provided by respondents, such as task efficiency, team communication, collaboration, and innovation.

A relationship was noted regarding the role performed in the team and the assessment of the team leader's performance. Individuals who were not team leaders assessed their leader's performance more positively than individuals who held this role while assessing their own work (Table 2).

Table 2.
Assessments of the team leader's performance

	Assessment of the team leader's performance	
	individuals who are not team leaders	**by the team leader**
Average ratings	8.40	7.53
Mean ratings	9	8

Source: Own research.

Based on the data, it can be observed that a team leader's performance rating of 10 was mainly given by team members, while ratings of 7, 8, and 9 for their own work were primarily awarded by team leaders. This suggests that team leaders may assess their own work lower than their team members do, possibly underestimating their contributions. No ratings below 5 were given for a team leader's performance, which may be related to the awareness of individuals participating in research and development teams regarding the high competency requirements for team leaders.

From the obtained ratings of team leaders and the basis for their selection, a certain pattern can be discerned. Leaders who possessed high substantive knowledge in the project area and were the originators of the project typically received higher ratings than other leaders. Other factors, such as managerial predispositions or the ability to create research plans and secure funding, may also influence the assessment of a team leader. However, based on the collected data, it cannot be conclusively stated how these factors impact the evaluation of the leader.

It is important to note that the assessment given to a project leader can be interpreted as a subjective score based on individual criteria and expectations. In some cases, the team and project leader assessments align (e.g., 10-10, 8-8), but there are also instances where the ratings differ (e.g., 8-5, 9-7). This implies that there is no direct correlation between these assessments. The evaluation of a project leader may also result from other factors, such as leadership skills, team management, communication, or achieved goals. It may also depend on the subjective preferences and expectations of the evaluator.

However, it is worth noting that the team and project leader ratings are somewhat correlated, as in some cases, similar ratings are assigned to both the team and the project leader. Nevertheless, there are also cases where the assessments differ for both sides. No clear correlation was observed between the team's performance assessment and the role played in the project.

Based on the collected data, associations between motivation and the role performed in the team can be observed:

- Team members demonstrate motivation primarily through research curiosity, career development, and the opportunity to meet other scholars. This may stem from their desire for learning, knowledge acquisition, and personal growth.
- Team leaders often mention financial motivation and career development. They may be more interested in earnings and professional advancement.

From the available data, it can be presumed that an individual's motivations for participating in a project influence the team's performance assessment, although it is not straightforward. Team members with strong motivations, such as research curiosity, career development, a desire to do meaningful work, financial motivation, or the opportunity for international travel, often gave higher ratings for teamwork.

However, individuals who reported fewer motivational reasons tended to give lower scores. Motivations can influence engagement, engagement affects team efficiency, and team efficiency is often assessed. Motivations can also influence the involvement and commitment of team members in project goals, collaboration, communication among team members, problem-solving ability, and creative thinking. However, it is important to note that the team's performance assessment may also depend on other factors, such as skills, communication effectiveness, collaboration ability, work organization, or resources available to the team.

Motivations are one element that can influence the assessment but are not the sole determining factor.

The impact of the number of roles according to M. Belbin's concept on the team's performance assessment is not conclusive. The calculated correlation coefficient is very low (0.06), indicating a very weak positive correlation between the number of roles performed and the team's performance assessment. This value is very close to zero, suggesting no significant linear relationship between these two variables based on the available data. No nonlinear relationship was observed either.

Based on the collected data, it is not possible to conclusively determine which role has the strongest impact on a high team assessment. However, concerning teams receiving the highest ratings (9 or 10), it can be observed that they often include individuals with roles such as Creator, Specialist, Perfectionist, Evaluator, Coordinator, Implementer. These roles have different characteristics and skills that are important for effective teamwork.

There seems to be some influence of the percentage of women in the team on the team's performance assessment. Of course, this is not the sole determining factor, but certain tendencies can be discerned. Teams with a percentage of women ranging from 41-59% tended to receive ratings of 8, 9, or 10. Teams with a higher percentage of women tended to receive slightly higher ratings. However, this is not a strict rule, as there are also cases where teams with different percentages received different ratings. The results would, however, support the advantages of gender-diverse teams.

One can also observe a certain relationship between the number of problems and the team's performance assessment. The lower the number of problems reported by the team, the higher the team's performance rating. For instance, most teams reporting only 1 or 0 problems received very high ratings ranging from 8 to 10. Conversely, teams reporting a higher number of problems, such as 3, 4, or 5, tended to receive lower ratings in the range of 4 to 7. However, it should be noted that these data do not account for other factors that may influence the team's performance assessment. Other factors, such as problem-solving effectiveness, work efficiency, team communication, and many others, may also be relevant to the team's performance assessment.

Based on the provided data, relationships between the type of problem occurring in the team and the team's performance assessment can be identified:

- Administrative-economic problems: Many teams reporting administrative-economic problems received ratings in the range of 8-10. Problems of this type did not have a significant negative impact on the team's performance assessment.
- Insufficient sense of responsibility among team members: Teams reporting an insufficient sense of responsibility among team members received various ratings, but most commonly ratings ranged from 8-10.

- Inappropriate selection of individuals for the team and ineffective task allocation: Teams reporting problems related to the inappropriate selection of individuals for the team and ineffective task allocation received varied ratings, but often lower ratings in the range of 4-7.
- Lack of problems: Teams reporting no problems received varied ratings, but most commonly ratings were in the range of 8-10. The absence of problems does not necessarily guarantee a high rating, but it can be a favourable factor.

Further analysing the issue of problems, one can notice a certain impact of the number of problems on the assessment of the team leader's performance – the lower the number of problems, the higher the leader's rating. However, there are also cases where, despite a higher number of problems, the leader's rating remains high. Thus, while the number of problems may have some impact on the assessment, it is not the sole determining factor. Other factors, such as effective problem management, an approach to problem-solving, and the overall quality of the leader's work, also influence the assessment. Administrative-economic problems in the project have a negative impact on the leader's rating. Additionally, inappropriate selection of individuals for the team, ineffective task allocation, and improper work organization also affects the rating. On the other hand, the absence of problems or a limited number of project-related problems contributes to a higher leader's rating.

Staying on the topic of problems, it is challenging to unequivocally determine which role has the worst impact on the team's performance rating because the ratings are diverse, and there is no clear trend. However, based on the available information, one can observe that the 'Victim' role often appears in the context of a negative team performance rating. An individual in this role constantly faces difficulties, requires support from others, and utilizes their energy at the expense of the group's work. Also, the 'Passive' role, which withdraws from the assigned task, marks work and highlights a lack of interest in the team and the work, is also often associated with negative ratings. However, the team with the lowest received score (a rating of 3) was the only one to note the 'Aggressor' role in their team. Critics of B. Tuckman's model suggested that a team may be at more than one stage simultaneously (Czahajda, 2019). The results of the research conducted among research and development teams confirm this argument (Figure 16).

There is a correlation between the team's performance evaluation and the stage at which the team is situated. The results suggest that the team receives higher ratings when it is in the execution phase, working efficiently, implementing new creative solutions, and benefiting from a goal-oriented atmosphere. The evaluation is also positive in the normalization phase, where the team transitions from conflicts to substantive discussions, openness to exchanging views, and mutual support. However, in the forming phase, where the team is cautious, uncertain, searching for direction, and avoiding conflicts, the team's performance evaluation is lower. Similarly, in the storming phase, where conflicts manifest in all aspects of the team's functioning, the evaluation also tends to be lower. In the closure phase, when collaboration ends due to goal achievement or when all members leave the team, the team's performance evaluation remains stable at the level of 8 or 9.

5. Conlusions

Considering the presented data and analysis, it can be inferred that evaluating the team's performance in the context of various factors, such as the developmental stage, the number of reported issues, or participants' motivations, sheds new light on the dynamics of research and development teams. Identifying connections between these elements allows for a better understanding of how different aspects impact the effectiveness and assessment of team performance. However, it is worth emphasizing that evaluating team performance is a complex issue, dependent on various factors, and requires a holistic view of the functioning of the R&D team. These findings may serve as a starting point for further research on team building in project teams and can be inspirational for practitioners aiming to optimize collaboration in R&D teams.

What is necessary to emphasize is that this article presents the results of quantitative research without considering qualitative research. These will be presented in the next article.

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References

1. Belbin Polska (2023). *belbin.pl - role zespolowe Belbina*. https://www.belbin.pl/role-zespolowe-belbina/, 5.07.2023.
2. Creswell, J.W. (2013). *Projektowanie badań naukowych. Metody jakościowe, ilościowe i mieszane.* Kraków: Wydawnictwo Uniwersytetu Jagiellońskiego.
3. Czahajda, R. (2019). Oficjalna strona internetowa Unii Europejskiej - EPALE - Blog. https://epale.ec.europa.eu/pl/blog/dlaczego-tuckman-nie-jest-dobrym-modelem-opisujacym-proces-grupowy, 5.07.2023.
4. DiSC Polska (2020). *Metoda DiSC*. https://disc-polska.pl/disc/, 5.07.2023.

5. Drążkiewicz, B. (2022). *Talenty Gallupa – czym są i jak wykorzystać je w zarządzaniu*. https://mobiletrends.pl/talenty-gallupa-w zespole/, 5.07.2023 06.15.2023.
6. Effectiveness (2023). *Analiza zespołu DISC D3 (Mapa zespołu).* https://effectiveness.pl/analiza-zespolu-disc-d3-mapa-zespolu/, 5.07.2023.
7. Feng, B., Jiang, Z.-Z., Fan, Z.-P., Fu, N. (2010). A method for member selection of cross-functional teams using the individual. *European Journal of Operational Research*, pp. 652-661.
8. FRIS® (2023). *Model FRIS*. https://fris.pl/, 6.15.2023.
9. Hackman, R., Vidmar, N. (1970). Effects of Size and Task Type on Group Performance and Member Reactions. *Sociometry*, pp. 37-54.
10. hrpolska (2015). *Idealne zespoły czy zamki na piasku?* https://hrpolska.pl/zarzadzanie/narzedzia/idealne-zespo-y-czy-zamki-na-piasku, 6.15.2023.
11. Kisielnicki, J. (2018). Projekty badawczo-rozwojowe: charakterystyka i znaczenie. *Studia i Prace Kolegium Zarządzania i Finansów,* pp. 25-43.
12. Kopczewski, M., Szwarc, E. (2009). Wykorzystanie techniki MBTI w budowaniu. Opole: WNT. https://reder.red/myers-briggs-type-indicator-28-11-2022/, 6.15.2023.
13. Kossowska, M., Sołtysińska, I. (2006). *Budowanie zespołów. Materiały szkoleniowe - ćwiczenia, formularze, wskazówki dla prowadzącego*. Kraków: Oficyna Ekonomiczna.
14. Krawczyk-Bryłka, B. (2012). Struktura i role w realizacji projektu badawczego. In: M. Wirkus, A. Lis, *Zarządzanie projektami badawczo-rozwojowymi* (pp. 84-103). Warszawa: Difin S.A.
15. Lencioni, P.M. (2002). *The Five Dysfunctions of a Team. J-B Lencioni Series*. London, England: Jossey-Bass.
16. Lencioni, P.M. (2023). *Sześć typów osobowości zawodowych. Jak zrozumieć talenty oraz frustracje swoje i całego zespołu*. Warszawa: MT Biznes.
17. Lucius, R.H. (1996). Using Sociometry to Predict Team Performance in the Work Place. *The Journal of Psychology*, pp. 21-32.
18. McShane, S., Von Glinow, M.A. (2017). *Organizational Behavior*. Great Britain: McGraw-Hill Education.
19. Omar, M., Syed-Abdullah, S., Mohd Hussin, N. (2011). Developing a Team Performance Prediction Model: A Rough Sets Approach. *Informatics Engineering and Information Science.* Berlin/Heidelberg: Springer, pp. 691-705.
20. Pauli, U. (2007). Wykorzystanie modeli kompetencyjnych w doborze członków zespołów projektowych. *Zeszyty Naukowe Akademii Ekonomicznej w Krakowie*, pp. 115-128.
21. Pawlak, M. (2006). Fazy tworzenia zespołu projektowego. *Roczniki nauk społecznych, tom XXXIV*, pp. 249-271.
22. Taraszkiewicz, M., Nalepa, K.F. (2007). Zespół, praca zespołowa i praca w zespole. *CODN*, p. 8.

23. Tsai, H.-T., Moskowitz, H., Lee, L.-H. (2003). Human resource selection for software development projects using Taguchi's parameter design. *European Journal of Operational Research,* pp. 167-180.
24. Twardochleb, M. (2014). Dobór zespołów projektowych z wykorzystaniem metod stochastycznych. *Informatyka Ekonomiczna*, pp. 223-236.
25. Wirkus, M., Lis, A. (2012). *Zarządzanie projektami badawczo-rozwojowymi*. Warszawa: Difin.