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Optimal selection of team members according to Belbin's theory

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Abstract
In the modern economy, effective teamwork is essential in the majority of industries. Teams of specialists such as crewmen and software developers need to be able to work together properly. The appropriate selection of team specialists according to their soft competencies results in synergies, and streamlines tasks. This paper presents the results of studies aimed at assessing the impact of team role configurations on overall team performance.

Introduction

Widespread education lies at the root of the rapid economic development seen during the twentieth century and continuing today. With the development of new technology, education has become increasingly specialized. Instead of people gaining general knowledge of a particular specialty, it became necessary for them to focus on a narrow sub-specialty. One negative consequence of this overemphasis on specialized education is that it has entailed a loss of broader communication skills.

The criteria for assigning work have fluctuated significantly over the years. Nowadays, Human Resource departments are increasingly facing problems when trying to recruit the ideal employees, and hence developing new methods for this purpose, as shown in Table 1. Applicants submit diplomas confirming their education, certificates for specialized courses, and references from previous employers regarding their previous experience, but these documents do not give a clear indication of their soft skills (Belbin, 2010).

The recruitment of crew members for a marine vessel is based on candidates' education, specialization and previous experience – all confirmed by a stack of files. It is difficult, however, to make conclusions about these applicants' soft skills merely on the basis of formal documents. A newly hired employee will become a member of the team, so it is important to evaluate his or her teamwork skills and ideal team role. The team that the new employee will join

Table 1. Human resource strategies throughout the ages (Belbin, 2010)

Era	Criteria for assigning work	Method
Pre-industrial	By category: – Age – Sex – Tribe – Class	Visual inspection
Industrial	By qualifications: – Trade skills – Experience – Education	Cartificates, Selection panel
Post-industrial	By person shape: – Team role – Personal orientation	Computer matching, Counselling interview

already has a certain configuration according to the team roles and personal characteristics of the existing members, so the new member's profile should complement this. For example, assigning a new member with strong leadership instincts to a team that already has a strong leader may lead to conflicts or at least frustration in the future.

Nowadays teams commonly consist of specialists from a particular industry, e.g. ship mechanics or software developers, who need to work together in a closed environment. In this paper, an examination of the effectiveness of several teams' performance according to M. Belbin's "Team Role Theory" is presented.

The term "team role" describes specific behaviors, personal contributions, and relationships with others in the workplace. In the ideal team, each participant can demonstrate his or her own characteristics at different stages of the project and in all kinds of situation – normal maintenance, minor mishaps, and emergencies.

Each person has one dominant role, determined by the results of the Belbin questionnaire, as well as two or three secondary roles. Our dominant, or natural, role is the one in which we feel most comfortable and in which we function most effectively. If there is a personal deficit in the team, we can often play two or three roles successfully. However, if we are forced to play a role that too strongly contrasts with our dominant role, it can quickly result in frustration and lower the efficiency of the whole team.

A good team usually needs some time before it can start working efficiently. A group of people is not a team. To become a team, they need to have a common goal. First of all, they must be aware that by combining their various strengths they can reach their goal more quickly and easily. The most important goal when creating a team is to achieve a positive synergy effect, i.e. to achieve a total result greater than the sum of individual actions.

Teamwork issues are broadly described in the context of project teams (Belbin, 2004; 2010). The best results are achieved by teams that have varied levels of test results for intelligence. According to Belbin's research, the best performance was observed in teams that had a very intelligent creator, a second intelligent member, a chairman with an intelligence slightly above average, and remaining members with an intelligence slightly below average. The best teams were formed when members could acknowledge their shortcomings and account for them. The highly creative person was a great asset – but only when he was relieved of the duties for which the chairman was responsible. A visionary needs an opponent to debate in order to get the best possible outcome. Each team must have a person who can spot any errors and defects. People with weaker intellectual results were looking for other team roles in which they performed. Teams with a greater range of team features achieve much better results. In fact, uniformly high-intelligence groups had more failures than heterogeneous teams.

A proper division of responsibilities is the most important factor in a team's success. When every team member finds a role that corresponds to their skills and personality traits, this is a strong indication of a good team. In inferior groups, the team members would perform tasks in which they had already gained experience, but these tasks did not necessarily correspond to their personality traits, even if they did not realize it themselves.

The purpose of this study was thus to investigate the effect of occurring team roles on the performance of a team consisting of people with similar hard skills. The tested teams had four members, though Belbin says the ideal team should consist of eight people. However, given that the four-person teams tested had only a simple task to perform, their numbers were considered sufficient.

There are several previous reports assessing the performance of teams in relation to Belbin's team role occurrence. For example, in Smith, Polglase & Parry (2012), a large group of undergraduate students (116 to 146) was observed. They were familiar with the ideas of a team role assessment, and after implementation of the Belbin team role analysis, the average mark improved slightly. The introduction of the Belbin scheme was found to be a positive development to the study module by its coordinator.

In Batenburg, van Walbeek & in der Maur (2013), the relationship between Belbin role diversity and team performance was examined. In this study, 24 group of 144 students were participating in different rounds of a management game. They also performed a Belbin role self-test prior to the game. The results of the performance analysis shown that team role diversity had no correlation with team performance.

We may therefore conclude that different studies have arrived at contradictory results. It is possible that the subjects' awareness of being investigated causes some distortion bias or confirmation bias that affects their behavior. In order to avoid this interference, the following experiment was conducted in a different way, described in the next section.

Methods

The study was conducted using a questionnaire in Polish, which was the native language of respondents. All respondents represented one industry – IT engineering (in spe) – so it was assumed that each of them had specialized qualifications. The study was therefore conducted for the selection of eight team roles, as the role of the "specialist" in the nine-item questionnaire (Belbin, 2004) is generally consistent with the education and professional profile of the respondents. A questionnaire based on validation studies by Stanisław A. Witkowski and Sławomir Ilski on translations by Barbara Kożusznik and Dorota Ekiert Grabowska (Witkowski & Ilski, 2000) was used.

The eight team roles used in the questionnaire were as follows:

- Company Worker (CW). Takes colleagues' suggestions and ideas and turns them into positive action. They are efficient and self-disciplined, and can always be relied upon to deliver on time.
- Chairman (CH). A likely candidate for the chairperson of a team, since they have a talent for stepping back to see the big picture. Chairmen are confident, stable and mature, and because they recognize the abilities of others, they are very good at delegating tasks to the right person for the job.
- Shaper (SH). A task-focused individual who pursues objectives with vigor, and who is driven by tremendous energy and the need to achieve. For the Shaper, winning is the name of the game. The Shaper provides the necessary drive to ensure that the team is kept moving and does not lose focus or momentum.
- Plant (PL). A creative and unorthodox generator of ideas. If an innovative solution to a problem is needed, a Plant is a good person to ask.
- Resource Investigator (RI). Provides the team with a rush of enthusiasm at the start of the project by vigorously pursuing contacts and opportunities. He or she is focused outside the team and has a finger firmly on the pulse of the outside world.
- Monitor/Evaluator (MO). A fair and logical observer and judge of what is going on within the team. Since they are good at detaching themselves from bias, they are often capable of viewing all available options with the greatest clarity and impartiality.
- Team Worker (TW). The oil between the cogs that keeps the team engine running smoothly. They are good listeners and diplomats, talented at resolving conflicts and helping team members understand one another without becoming confrontational.
- Completer/Finisher (CO). A perfectionist, who will often go the extra mile to make sure everything is "just right." His or her work can be trusted to have been double-checked and then checked again. The Completer/Finisher has a strong inner sense of the need for accuracy, and is capable of setting his or her own high standards rather than relying on the oversight of others.

See (Belbin, 2004) for a more detailed description of the team role profiles.

Data was collected through a website survey. The only open questions concerned the name of the respondent and his or her fellow team members. The rest of the questions were closed. The questionnaire was divided into seven parts, each of which had eight sub-points. The respondent had unlimited time to split ten points into each of the seven parts. The sum of ten points can be assigned to a single sub-point, or distributed at the respondent's discretion.

Team role strength was examined based on Table 2. Note that for the role of Shaper (SH) and Team Worker (TW), assigned strength is different for male and female respondents.

Table 2. Team work strength calculation matrix (Witkowski & Ilski, 2000)

Strength / Team role	Very low	Low	Medium	High	Very high
CW	0–3	4–8	9–13	14–18	19–21
CH	0–1	2–4	5–8	9–12	13–15
SH	0–1 F 0–3 M	2–6 F 4–9 M	7–11 F 10–14 M	12–17 F 15–20 M	18–20F 21–24 M
PL	0–1	2–3	4–7	8–11	12–14
RI	0–1	2–5	6–9	10–13	14–16
MO	0–1	2–6	7–11	12–16	17–19
TW	0–1 F 0–1 M	2–8 F 2–4 M	9–14 F 5–10 M	15–20 F 11–15 M	20–25 F 16–19 M
CO	0–1	2–7	8–13	14–19	20–22

The test was conducted on a group of 24 people: 10 women and 14 men. They belonged to 6 separate project teams. Most of these teams were mixed, with only one team consisting entirely of men. The answers were provided by third-year students, soon to be engineers, from the Faculty of Computer Science and Information Technology. The questionnaires were completed in late May, 2016.

The study was conducted in terms of team role occurrence in student teams. The results of the questionnaires were compared to the team project scores

received by the teams, according to the Polish academic grading scale, which is as follows:

2.0 – insufficient (negative);
3.0 – sufficient;
3.5 – better than sufficient;
4.0 – good;
4.5 – better than good;
5.0 – very good, excellent.

The team's performance was examined by an independent teacher who had not previously studied the team roles of the students and their teams. Thus, the students' marks were based solely on the results of the teams, regardless of the results of the survey. The basis of the final mark was the quality of the project developed through the semester during a "Team Project" module. Moreover, the Belbin questionnaire presented to the students at the end of the semester did not directly reveal the interpretation of their results. This allowed the teacher to make his or her assessment of the team independently, and meant that results could not be biased by an eventual knowledge of occurring team roles among students.

Results

The results of Belbin's questionnaire are presented by the charts in Figure 1.

As we may observe in Figure 1, the results of the Belbin survey are different throughout the teams. The bars' height represents the strength of the corresponding team role (CW, CH, etc.) in relation to one of the four team members (1x – 4x), where "x" refers to the subject's gender (Male/Female).

A summary of the survey results is presented in Table 3 below. Where the role strength is low or very low, it is indicated by gray or dark gray respectively. A high role strength is typed in bold and a very high role strength is bold-underlined. The right column represents the final grades received by teams.

Among the six teams evaluated, only one (Team B) received a negative grade from the study course, while the other five received positive ones. These positive results varied, however.

According to Belbin's theory, a representation of all team roles is necessary for a team to function

Table 3. Collective results of surveys conducted on student teams, based on (Markowski, 2016)

Teams	Members	CW	CH	SH	PL	RI	MO	TW	CO	Grade
A	1M	12	4	10	**8**	**10**	**13**	4	9	3.5
	2M	6	2	10	7	**11**	**25**	7	2	
	3M	10	**13**	8	**8**	6	4	**13**	8	
	4M	9	5	**28**	3	**14**	2	0	9	
B	1M	8	**12**	8	6	**13**	**11**	7	5	2
	2M	5	**12**	10	**11**	8	9	9	6	
	3F	10	**9**	6	**10**	7	8	13	7	
	4F	11	6	7	6	**9**	**12**	12	7	
C	1M	12	6	4	**17**	9	8	6	8	4
	2F	7	**25**	8	2	**20**	6	2	0	
	3F	7	8	11	**8**	6	9	13	8	
	4M	1	**27**	**19**	2	**16**	1	2	2	
D	1F	5	**25**	5	2	5	4	**21**	3	4
	2M	9	1	**15**	**13**	5	9	**12**	6	
	3F	13	5	**13**	3	8	7	1	**20**	
	4M	13	8	13	**8**	4	**13**	4	7	
E	1M	7	5	**16**	6	**10**	7	9	10	4.5
	2F	6	4	**13**	4	7	**17**	1	**18**	
	3F	12	**13**	8	6	6	9	7	9	
	4M	7	**10**	**19**	**7**	**11**	7	4	5	
F	1M	9	**9**	5	**13**	7	5	**15**	7	3.5
	2M	5	**11**	10	**13**	5	9	**12**	5	
	3F	11	**16**	10	**10**	3	7	6	7	
	4F	9	5	7	**11**	8	8	12	10	

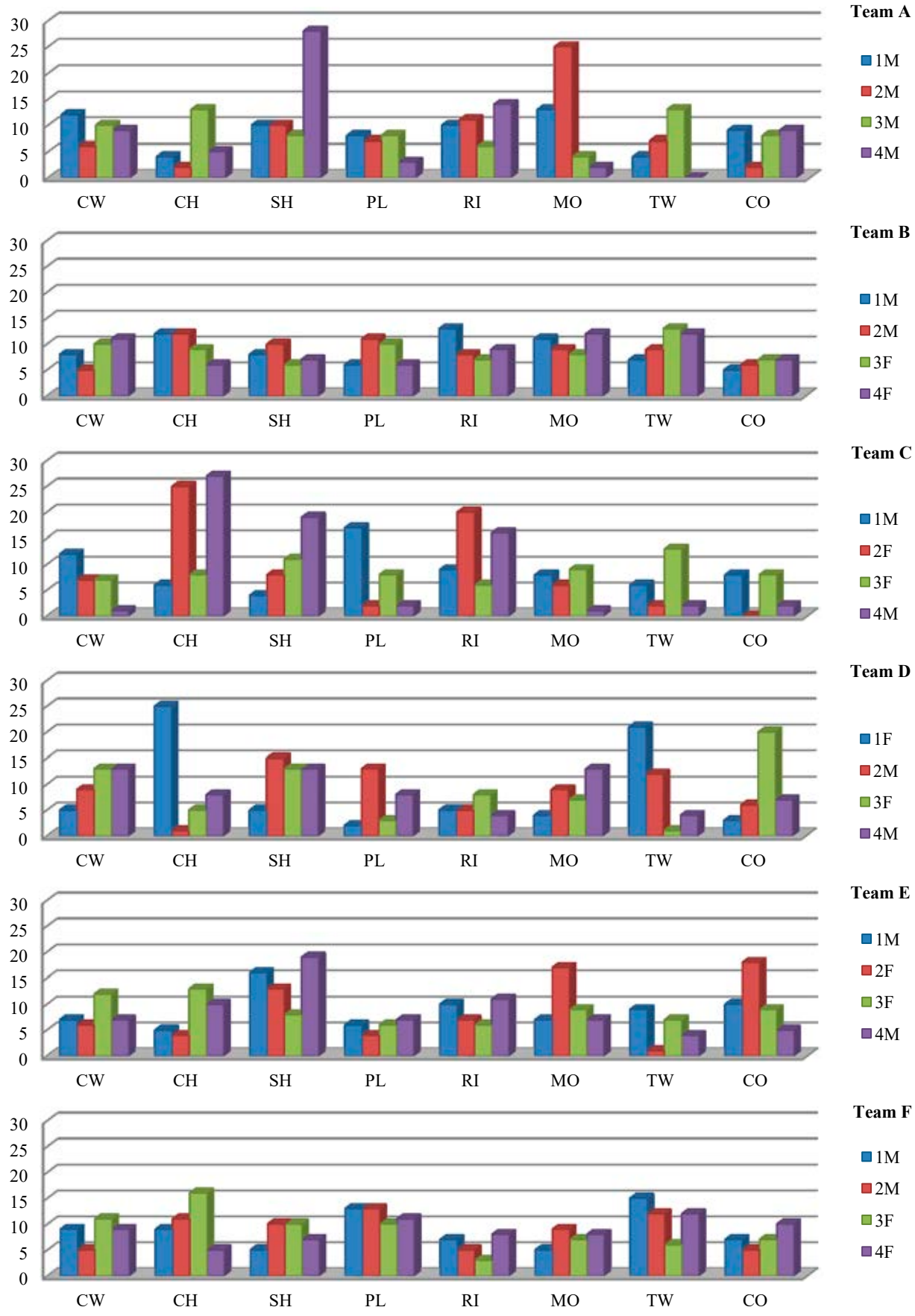

Figure 1. Results of surveys conducted on student teams (Markowski, 2016)

effectively and efficiently. As we may observe, the only team that scored negatively was the one deficient in a particular role. In Team B, none of the members had at least medium strength in the "Completer" role. We may also observe that none of the members of Team B has a "very high" strength in any given role. A "high" strength was present in only four of the eight total roles. Furthermore, three out of four members of Team B had the same "high" strength in relation to the "Chairman" role. It may be assumed that such a composition, whereby the team lacked a Completer and had three leadership-seeking members instead, resulted in the negative final score.

For the other teams, having all the team roles represented by at least "medium" strength apparently resulted in a positive course grade. We may notice that among the examined population, no subjects were rated at least "high" for the "Completer" role.

Further examination of results shows, for example, the following:

- Teams A and F scored the same grade regardless of significant differences in the number of "very high" and "high" scores for team roles. As can be observed, Team A had four team roles at "very high," and another two at "high" strength, while Team F had only two "very high" results and another two at "high" strength. Despite this difference, the final result of both teams was 3.5, which corresponds to a "better than sufficient" rating.
- On the other hand, Team E (which achieved the highest ranking of 4.5 [better than good]) had two team roles rated at "very high" and another three roles rated at "high" strength. Meanwhile, members of Team D, which scored 4.0 (good), had four roles rated at "very high" and another two rated at "high" strength.
- Team C was an example of the "doubling" of team roles: two members (2F and 4M) were rated as having a "very high" strength for the "Chairman" and "Resource Investigator" roles. Every role on this team was at least at "medium" strength, however, so the team managed to score a final grade of 4.0 (good).

The results we observed led us to attempts to develop an aggregated scoring of the team based on the composition of the team role strengths of their members. The proposed aggregate is a weighted sum of the number of team roles and their representative strengths.

The weights should correspond to the levels of the roles, but moreover, having observed the highly negative impact of the missing team role, we decided to set a penalty weight in case a given team role did not appear at least at medium strength. An occurrence of the very high role was awarded with a weight of 4, as it is apparently the most needed one; the high role was awarded a weight of 2, and the occurrence of at least medium was awarded a weight of 1. As we had observed the highly negative impact of the missing team role (rated as low or very low) on team's performance, these gaps were penalized with a weight of –20.

Thus, the Aggregated Team Ratio can be described as:

$$\mathrm{ATR} = \sum_{i=1}^{n} w_i \cdot a_i$$

where:

$i = 1$, $w_i = 4$, a_i – Number of team roles occurring in the team at least once at 'very high' strength;

$i = 2$, $w_i = 2$, a_i – Number of team roles occurring in the team at least once with maximum strengths of 'high';

$i = 3$, $w_i = 1$, a_i – Number of team roles occurring in the team at least once with maximum strengths of 'medium';

$i = 4$, $w_i = –20$, a_i – Number of team roles never occurring in the team with maximum strengths of at least 'medium' – penalty for missing team roles.

According to surveys results and proposed weights, the Aggregated Team Ratio (ATR) values for examined teams are as following:

team	ATR	Grade
A	22	3.5
B	–9	2
C	18	4
D	22	4
E	18	4.5
F	15	3.5

Additionally, the Pearson Correlation Coefficient between ATR and the performance of a team reflected in its final grade was calculated. We may notice the high correlation of these: 0.87. This may lead to the conclusion that the performance of a team is highly dependent on its ATR, which itself corresponds to the optimal configuration of team roles.

Discussion and conclusions

Our analysis of team role configuration confirmed that an occurrence of all roles is a crucial factor in a team's performance. In particular, the highly negative impact of a shortage in any given role was observed. A deficiency in one role, combined with

double or triple occurrences of other roles, meant that the team was unable to complete its task.

As we may notice, the result was obtained in a double-blind experiment. Neither students (the subjects of the study) nor the teacher (the evaluator of the subjects' performance) were aware of Belbin's theory. We may therefore assume that the results are free of the "Rosenthal effect," where expectations influence outcomes (Rosenthal & Jacobson, 1968). Hence, the study was performed in different conditions than those mentioned in the Introduction section (Smith, Polglase & Parry, 2012; Batenburg, van Walbeek & in der Maur, 2013). Further research should focus on a larger population, in order to confirm the utility of our proposed Aggregated Team Ratio or to improve it by correcting the weights we have proposed.

As an example for practical use, we may also propose a single-blind experiment, in which students working on team projects will be allocated to the teams using Belbin's questionnaire at the beginning of the semester, instead of the team building being done at random. The results show that in the selection team members, it is important that each member has an identified team role. Through such a method, it will be possible to match them to optimal teams.

For a large population of workers, the results may also be relevant to another problem related to the optimal assignment of the available workforce to different projects or tasks. For example, it may assist with optimally dividing 100 people for 20 separate tasks. In this case it may be necessary to apply optimization methods, from simple ones such as Monte Carlo (Twardochleb, 2014) to more advanced ones such as genetic algorithms (Rejer, 2015) or hybrid methods (Pietruszkiewicz, Twardochleb & Roszkowski, 2011; Twardochleb, Król, Włoch & Kuka, 2013). Using these methods will allow for the allocation of available staff to teams in such a way as to maximize the synergy effects of all team roles.

The results presented indicate the high importance of proper selection of members to a team of specialists. They may be used, for example, in the selection of a team of mechanics for a ship engine room, where a high-class group of specialists must be capable of working together, especially in emergency situations. The occurrence of the appropriate set of soft skills and team roles will ensure a higher quality of outcomes. This is a key goal, especially in sectors such as the maritime industry that require high reliability.

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