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GUIDING TEAM SELECTION AND THE USE OF THE BELBIN APPROACH

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1. Introduction

A move from individual to team working has occurred during the last 25 years, affecting engineering through to city finance [Burch & Anderson, 2004]. Individuals are more often working collaboratively in engineering design [Coker & Coker, 2004]. Many products, such as aircraft, are now highly complex and require expertise from a wide range of areas. The effect of increased global competition in recent years has led to reduced product life cycles and consequently a need for shorter lead times on product development [Swink, 1998]. This trend has also led to companies outsourcing both design and manufacturing. For example, the design of the A380 wing involves more electronics than any previous wing. Here there is a requirement for engineers from many backgrounds such as composites, electronics and structures to work together. In this case, Airbus uses suppliers to design systems for their aircraft. This occurs across many sectors and the key importance for companies is to ensure they reap the benefits of team working. Research showing how to improve teams through team building has been undertaken by McCarthy [2005]; and teaching team working and skills by Seat & Lord [1998]. It has been suggested this may be a more efficient way of producing good teams than focusing on selection [Manning et. al., 2006]. However, the aspect of team selection remains important [Kinna, 1995]. The aim of the research reported in this paper is to focus on the use of the Belbin technique to select a number of teams and then assess the technique as a measure of team performance.
The overall aim was to assess whether the Belbin approach was effective and whether the future selection of trainee engineering teams could be enhanced.

2. Approaches for selecting an effective team – Literature Review

To avoid ambiguity the following definitions are used in this review of the literature. A **Knowledge Area** being the expertise or specialisation of an individual e.g. stress analyst. **Personality traits**, aspects of character or behaviour specific to an individual. **Personal Skills** being the individuals interpersonal and teamwork skills, usually a reflection of their personality traits and **Diversity,** the distribution of personal attributes or traits amongst teams.
There is much literature on what makes a good team, irrespective of knowledge areas, which focuses on psychological aspects such as personal skills and personality traits. As may be expected it has been found that the personality composition of a group to be positively related to its effectiveness [Halfhill et. al., 2005]. The models presented in this literature review all have shared roots in the sixteen-personality factor structure (16PF). Cattells' 16PF has been a widely used tool in applied psychology since its release in 1949. The large numbers of variables used to describe personality were reduced by factor analysis, until simplified to the sixteen underlying primary traits which could be used to describe the set [Cattell & Catell, 1995]. These were validated using 25, 000 subjects. [Cattell & Krug, 1986]. Using this as the basis three models were identified for further review, the big five personality

traits, the Myers-Briggs type indicator and the Belbin self-perception inventory. A detailed review of the literature can be found in Wasiak [2007].

2.1 The Big Five Personality Traits

The model of *"The Big Five Personality Traits*" (B5) was proposed by Lewis Goldberg [1993]. The factors were identified as; Agreeableness, Conscientiousness, Extraversion, Neuroticism and Openness to Experience. Investigation of these traits has shown teams with high levels of agreeableness, extraversion and low levels of neuroticism to be more effective [Driskell et al., 2006].

2.2 The Myers-Briggs Type Indicator

The *Myers-Briggs Type Indicator* (MBTI) developed by Katherine Cook Briggs and Isabel Briggs Myers highlights personal preference for contrasting characteristics: extraversion vs. introversion; sensing vs. intuition; thinking vs. feeling; judging vs. perceiving [Myers, 1980]. It is similar to B5 in that it examines **personality traits**. Its scientific basis and validity have been seriously questioned, [Pittenger, 2005] but despite this it is widely used.
A model for team selection based on the MBTI has been proposed which encourage specific traits, Extraversion, Thinking and Judging, whose presence improves team performance [Peslak, 2006].

2.3 The Belbin Self-Perception Inventory

The Belbin Self-Perception Inventory (BSPI) identifies *Roles*, or personal skills linked to groups of personality characteristics, rather than personality types [Belbin, 1981]. In this sense it is different from B5 and MBTI. The *Role* names: Plant (PL), Resource Investigator (RI), Coordinator (CO), Shaper (SH), Monitor Evaluator (ME), Team worker (TW), Implementer (IMP), Complete finisher (CF), Specialist (SP), are intended to be descriptive [Belbin Associates, 2007]. The plant for example, represents someone who sits on the side like a house plant and fails to interact much with the group [Henry & Stephens, 1999]. Full descriptions of the Roles are shown in table 1. Belbin suggests that a good team could comprise of an even distribution of these *Roles*. That is to say, one of each *Role* should be present. His work also suggested that different combinations or weightings of *Roles* in a team might vary its ability concerning the task. However, the experiments establishing the *Roles* were based on only two tasks. These were both trading games in which teams played as companies, aiming to win the game by recording the highest profit. Scepticism of Belbin's work exists; with Jackson [2002], proving that amongst his experimental teams Belbin *Roles* did not predict performance. Here teams with a presence of each Belbin *Role* were rated higher than teams with missing *Roles*. The performance of the teams was then measured for a task, which involved a riddle solving orienteering exercise. Furnham & Steele [1993] undertook analysis of Belbin's theory. They determined that although the classifications or *Roles* may be valid, the designed test did not produce accurate or reliable results. Despite this Belbin's research was described as ***"substantial and imaginative"*** [Furnham et. al., 1993].
Criticism has been made of its Ipsative nature [Furnham & Steele, 1993; Jackson, 2002]. Sommerville & Dalziel [1998] gave Likert and Ipsative versions of the BSPI to subjects and found negligible difference in test results. The concept of a team fit to a task environment was investigated covering a limited sample of managers concluding that RI and PL's with no IMP or CO's was advantageous where there were variable or scarce resources. More stable tasks were suited to IMP and CO's without RI and PL's [Shi & Tang, 1997]. Other evaluation of BSPI found that it enables positive features of a team to be encouraged or selected [Rajendran, 2005]. For example, selecting only one strong leader [Henry & Stephens, 1999]. BSPI has been applied in many team selection models and investigations. Recently, in the engineering domain, a model was developed which allocated one domain of expertise per designer considering Belbin *Role* [Caillaud & Hadji-Hamou, 2004].
Despite its strong psychological base and wide spread use, BSPI has yet to be empirically or theoretically derived [Sommerville & Dalziel, 1998]. In comparing BSPI to B5, it has been suggested the B5 model offers benefits from relating team *Roles* to personality traits, and criticism has been made on BSPI selection rather than its improvement focus [Manning et. al., 2006]. From the review of

literature several tools, Belbin, MBTI, B5, have been identified for forming teams. These tools have been discussed on a variety of levels. At the lowest level, authors have simply applied them, moving on to validating them, then evaluating them. At the top level tools have been modifying and applied in a specific own model. The overall findings from the literature indicated that each of the approaches applied within team selection had advantages and disadvantages. None of the tools was without criticism. The discussion of Belbin's team *Roles* and the BSPI has shown that there are serious concerns about its psychometric validity although its concept is popular. Other alternative models, the MBTI and B5, which do not offer a pattern for team formation as distinct as Belbin have received an equal amount of criticism. It was therefore judged that the Belbin model was as good as any to use when evaluating psychological aspects of experimental teams. The results however were to be treated with the appropriate degree of caution.

Table 1. The nine Belbin Roles (adapted from, Belbin Associates, 2007).

Team Role Descriptions		
Team Role	Contribution	Weakness
Plant	Creative and imaginative. Can solve difficult problems.	Not good at communicating due to being pre-occupied.
Resource Investigator	Communicates well and builds up contacts. Extrovert and investigates opportunities.	Once initial excitement is finished – loses interest. Over optimistic.
Co-ordinator	Good communicator and chair person. Good focus on goals and delegates well. Promotes decision making.	Sometimes seen as manipulative and offloads their own work.
Shaper	Can overcome obstacles. Does well under pressure and dynamic.	Can upset people. Prone to provocation.
Monitor Evaluator	Accurate judge, sees big picture. Strategic and discerning.	Does not have the ability to inspire others.
Team Worker	Diplomat, listens and averts conflict.	At critical and pressurised points is indecisive.
Implementer	Efficient and reliable. Turns ideas into practical solutions.	Not good at changing their mind and welcoming new ideas.
Completer Finisher	Completes on time, anxious and conscientious. Searches for errors.	Not good at delegating and worries too much.
Specialist	Single minded and provides skills that are rare. Dedicated.	Dwells on technicalities and provides a narrow skill set.

3. Research Method

For this research, a number of approaches were proposed to evaluate the current process and its performance. The following research questions were identified:

- How were the suggested *Roles* evenly distributed across the population?
- Had people with similar profiles clashed?
- Did general mental ability follow with team working ability?
- Had the teams most fitting Belbin's model performed better?
- Had similarly profiled groups with different tasks performed differently?

The methodology used consisted of data collection, sorting, observation of trends, investigation of results and forming proposals. These were integrated around information from the current literature discussed. Data showing (individual and group) academic scores and BSPI's was gathered. All of the group members completed a questionnaire in week eight of their project (after their feasibility report hand in and presentation). The questions designed to assess team ability, were based on the work by Higgs et. al., [2005] and asked team members about their opinions of other players in their group and how they felt their group was performing. Members were also asked to identify, from selection of characteristics present in good teams, their teams particular strengths and weaknesses. A second questionnaire obtained information about their tasks. This asked about the characteristics of the task such as its level of creativity, and whether the process followed was familiar to the team.

4. Analysing Team Performance – Pilot Study

The Department of Mechanical Engineering, as part of its Masters in Engineering degrees, runs a full time group design and business activity lasting fourteen weeks. Eighty-two trainee engineers from five

sub disciplines (mechanical, automotive, manufacturing, medical and innovation engineering design) are formed into teams of five or six members. The current team formation follows a set process. Prior to the team formations, all of the students complete the BSPI. Their academic averages from the previous year are also available. With this information, the aim is to produce balanced teams, in terms of Belbin *Roles*, with similar academic averages for each group. Although this can be achieved to some extent, the uneven distribution of *Roles* across the sample and constraints placed by the academic averages mean that significant differences often exist between the teams. Each team followed by this research was assigned a different task to complete which involved research, analysis, and teamwork. In most cases, tasks set by project supervisors were assigned arbitrarily to teams. However, three of the tasks were Medical Engineering based. All of the Medical Engineers were assigned to these tasks, although they were joined by others disciplines such as general Mechanical Engineers. After their formation, the teams selected their own leader. In some groups, the project supervisors made suggestions of suitable candidates (based on BSPI). In all teams, any team member could declare their willingness to stand as leader. Each year the projects consist of an initial five-week research and investigation period at the end of which teams submit feasibility reports for their task and give a presentation. The reports are individually written with each member focusing on different aspects of the task. In the second phase of the project teams continue with the development of their product, producing full technical reports and a business plan for how it may be manufactured and marketed. For this pilot study the aim was to investigate the teams and based on the findings propose improvement if appropriate for the design of the teams for future projects.

5. Results and Discussion

In this section some of the results, which have been used to propose enhancements to the current team selection process in the Mechanical Engineering department at the University of Bath, are discussed.

5.1 Distribution of Belbin Roles Across The Sample

The sample consisted of 80 trainee engineers forming 14 teams. The frequency of Belbin *Roles* across the sample was to be examined. The primary and secondary *Roles* of each team member were to be considered, with the overall findings to ascertain:

- If the distribution of primary *Roles* correlated with the distribution of secondary *Roles*.
- If the distribution of primary, secondary, or both *Roles* matched that seen by Belbin in his sample of UK managers [1981].

The distribution of Belbin *Roles* across the sample group was recorded [Figure 1]. The initial Belbin distribution [1981] is illustrated by the fourth column. The SP role is not shown as this was added in his later research findings.

5.2 Relationships Between

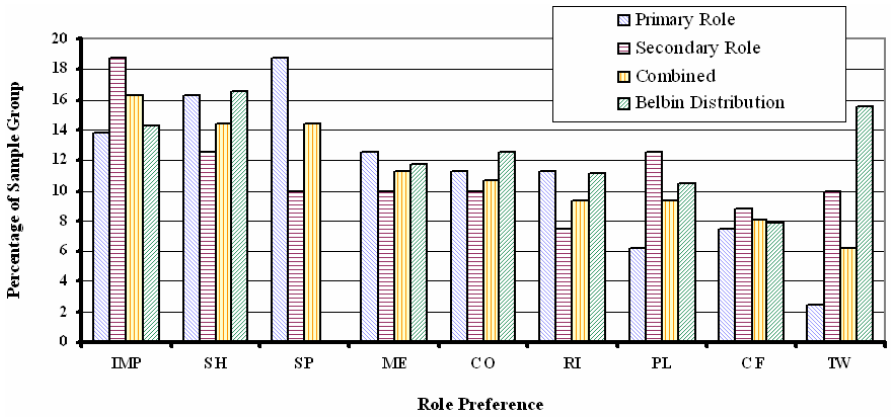

Figure 1. Frequency of Belbin Roles amongst the sample group

Belbin Roles and Academic Performance

This experiment was to identify whether a correlation between any Belbin *Roles*, and the academic performance of those fitting them occurred. For example, whether PL's were more academically inclined, as suggested by Belbin [1981]. The average scores for each role were examined as well as their distribution. Table 2 shows academic averages for the trainees primarily fitting each Belbin *Role*. The range of the marks is also shown. From this information, it appeared that CF's performed highly whilst TW's performed well below average. However when the frequency of these *Roles* was also considered, it was seen that these were based on a very small sample compared to the more common *Roles*. Whilst the most common *Role* of SH occurred 15 times, the TW occurred only twice. The *Roles* appearing most frequently had a wide range of marks and average scores close to 60%. Discounting the *Roles*, which occur with low frequency, generally there was no correlation between academic ability and Belbin *Role*. Although the *Roles* of CO and IMP, were well represented amongst the sample and performed a little above average academically.

Table 2. Academic Results For Students Primary Belbin Role

Belbin Role	CF	CO	IMP	ME	PL	SH	SP	RI	TW
Academic Average	64.2	63.5	63.2	61.5	60.8	60.7	59.2	53.3	47.5
Range	59-74	50.4-74.5	40.5-80.4	49.3-78	53-70	42.6-74	41.0-76.8	41.5-67.8	41.2-53.7
Primary Role Frequency	6	9	11	10	5	13	15	9	2

5.3 Contribution to the Group: Relations with Belbin Roles, Academic Scores

Members were identified by their teams (questionnaire) as the highest and lowest contributors of their groups. Where there was a consensus, the individuals Belbin *Roles* and academic performances were compared. The aim of this experiment was to identify:

- Whether certain *Roles* tended towards higher or lower levels of contribution.
- Whether individuals performing higher academically would be those who contributed more to their groups.

The *Role* and academic average data was examined for those noticed to have contributed especially highly or poorly. The *Role* of high contributors, Table 3, which occurred twice or more were CO SH SP IMP and ME's. One RI was also identified. This was a direct reflection of the distribution of primary *Roles* amongst the sample. An exception to this was the CO, taking a slightly larger than representative proportion, possibly due its occurrence as leadership *Role*. There was variation in academic ability showed that a lower achieving student may still be the most respected member of a team. However, the average score of 62 suggests that those with higher academic ability are more likely to be positive key players.

Those identified as the lowest contributing group members, 4, fitted *Roles*, which were again more frequent amongst the sample, with the exception of a TW. This suggests that no particular *Role* has a tendency to perform better or worse. The academic averages of the lower contributors again covered a range of marks, but had a lower total average of 55%, compared to 62% for the higher contributors. This reinforces the proposition there is a correlation between higher academic ability and the likelihood of contributing more to a team.

There were no significant correlations found between Belbin *Roles* and academic ability. CO and IMP *Roles* showed a tendency to perform slightly above average, but the applicability of this finding in a wider context was considered limited. Belbin's assertion that PL's were often of high IQ could not be translated to academic ability. Investigation on a wider sample could determine whether academic ability and IQ are more frequent amongst IMP and CO *Roles*.

It was found that teams whose tasks involved developing existing systems benefited from ME and RI representation in their teams. Teams whose task involved the creation of new and novel products

benefited from SP and PL *Roles*. It was proposed that when forming future teams, once these *Roles* have been allocated to every team, surplus players should be added to teams whose tasks may fit those described. A link between the presence of members with similar Belbin profiles and academic scores in a team and negative conflicts was found. It was not necessarily the case that the two similar members would conflict together but one of the pair was likely to become a poor player within the team. Future team selection should avoid placing members of similar *Roles* and scores in the same team where possible. It was found that all of the Belbin *Roles* were equally likely to be adopted by a team member who contributed the least or the most to their group. It was found that players of lower academic ability were more likely to contribute less and players of higher academic ability were likely to contribute more.

Table 3. High and Low Contributors and Academic Grades

	High Contributor		Low Contributor	
Frequency	Belbin Role	Academic Average	Belbin Role	Academic Average
15	SP	50	SP	59
	SP	47	SP	58
13	SH	72	SH	56
	SH	64		
11	IMP	72		
	IMP	65		
10	ME	55	ME	64
	ME	78		
9	CO	50		
	CO	72		
	CO	58		
9	RI	65	RI	41
2			TW	54
	Average =	62	Average =	55

6. Conclusions

In summary the key findings of the experiments were that:

- No correlation existed between academic ability and Belbin *Role*.
- Teams whose tasks involved developing existing systems benefited from ME and RI *Roles* represented in their teams.
- Teams whose task involved the creation of new and novel products benefited from SP and PL *Roles* represented in their teams.
- Players of lower academic ability were more likely to contribute less and players of higher academic ability were likely to contribute more.
- A link between the presence of members with similar Belbin profiles and academic scores in a team and negative conflicts existed.

With regard to the future of team selection for the group design and business projects for trainee engineers the following actions were recommended.

- Rather than aiming for an average 60% academic grade across the group a broader range from 50-65 % should accepted allowing selection with greater diversity of Belbin roles..
- Where possible, team selection should avoid placing members of similar *Roles* and scores in the same team.

Based upon the findings in this paper, an area of research worth investigating further is the affect of role selection with regards to task. Linking specific roles for design enhancements and novel designs. Hence, selecting the team mix based on the design task.

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