

Working as Part of a Balanced Team*

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The importance of teamwork within undergraduate engineering degree schemes has been recognised for a number of years. However, the establishment of such teams has traditionally been based on a stochastic method or the whim of the academic supervisor. This study was therefore undertaken to determine whether the selection of teams based on the Belbin technique would result in 'better' teams. Overall the results obtained support the use of this technique in defining the teams, although great care has to be taken in ensuring their potential is met.

INTRODUCTION

TEAMWORK has been an important aspect of Engineering Degree schemes for many years with the students undertaking some team-based activities in all years of study. However the emphasis on teamwork has grown in the last few years following the publication of SARTOR 3 in 1997 [1] where the newly defined M.Eng degree schemes had to include a team project. Since the inception of this degree scheme, the Mechanical Engineering students at Cardiff have been introduced to the 'theory' of good effective teamwork through a formal set of lectures in the second year of their studies. They then undertake two substantial team projects in the final year of their degree scheme. All the staff involved with these projects have noted that some teams never work well together, though there was no obvious reason for this lack of team cohesion. These 'problem' teams normally produced the worst work and their members were totally disheartened. A peer review exercise was introduced to ensure that the marks for each team member reflected their contribution to the team. However, this has not addressed the fundamental issue of why some teams never unite or work to their full potential. Since all the teams were treated in the same way, the reason for the identified problems could only lie in the composition of the team itself, which is in the combination of students placed together at the start of the project and expected to work as a team. A study was therefore instigated to investigate the importance of carefully selecting teams.

PREPARING FOR TEAM MEMBER SELECTION

The current scheme structure requires the Year 4 Mechanical Engineering students to undertake two out of three team projects that run concurrently

during the whole academic year. The three projects are:

1. The Automotive Design Project.
2. The Integrated Building Design Project.
3. The Power Transmission Design Project.

For the academic session 2002/03, 31 students choose the Building Project, 27 choose the Transmission Project and 16 choose the Automotive Project. In addition, a group of 5 ERASMUS students were also enrolled on the Automotive Design Project.

The number and size of the teams in each project were selected on different criteria. The Automotive Teams were self-selecting, with each team comprising members with a shared interest in a particular aspect of car design. The Transmission teams were selected by the academic project supervisor who balanced the academic profile of each team. The Building teams were selected on the premise that 'the best teams were balanced teams'.

In order to determine the balance of a team, the commercially available software GetSet™, an adaptation of the widely used INTERPLACE® system for people in the 16–23 age group was used, since the mean age of all the students was 22.6 years. The GetSet™ software is based upon the work of Meredith Belbin who undertook a series of research exercises into successful management teams [2]. He initially identified eight team roles that must be filled if the team was to be balanced, and therefore successful, in its mission. He defined a role as 'a pattern of behaviour characteristic of the way in which one team member interacts with another so as to facilitate the progress of the team as a whole' [2]. He labelled these team roles:

- Chairman,
- Company Worker,
- Completer/Finisher,
- Monitor/Evaluator,
- Plant,
- Resource Investigator,
- Shaper
- Team Worker.

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Table 1. The nine different roles

Team Role	Acronym	Descriptions	Contributions
<i>Completer Finisher</i>	CF	conscientious, painstaking, anxious	searches out errors and omissions, delivers on time
<i>Co-ordinator</i>	CO	confident, mature, a good chair-person	clarifies goals, promotes decision making, delegates well
<i>Implementer</i>	IMP	reliable, disciplined, conservative, efficient	turns ideas into practical solutions
<i>Monitor Evaluator</i>	ME	sober, strategic and discerning	sees all options, judges accurately
<i>Plant</i>	PL	creative, imaginative unorthodox	solves difficult problems
<i>Resource</i>	RI	extrovert, enthusiastic, communicative	explores opportunities develops contacts
<i>Investigator</i>			
<i>Shaper</i>	SH	challenging, dynamic, thrives on pressure	has the drive and courage to overcome obstacles
<i>Specialist</i>	SP	single-minded, self-starting, dedicated	provides knowledge and skills in rare supply
<i>Team Worker</i>	TW	co-operative, mild, perceptive and diplomatic	listens, builds, averts friction and calms the waters

Based upon further work he renamed the Chairman and the Company Worker as Co-ordinator and Implementer respectively and added a ninth role: Specialist [3]. These nine roles are the foundation stones of the GetSet™ programme and are described in Table 1.

Belbin also noted that each team member generally perceived themselves in some dominant roles (most preferred or natural team-roles), was able to adapt to some of the others (manageable or able to be assumed team-roles) and had no affinity with the remaining roles (least preferred team-roles). In order to identify the affinity of each team member with the nine specified roles, he developed a Self-Perception Inventory and an Observer Assessment Form. In order to fully classify the affinity of each role, the Self-Perception Inventory and at least four Observer Assessment Forms must be completed. An individual's role profile can then be defined, using the GetSet™ software which provides information based upon the Self-Perception Inventory, the Observers responses and a combination of the two.

Once an individual's role preference has been defined, a team's characteristics can then be defined by simply selecting the members of the team. This team profile provides an overall description of the team's attributes, including the relative strengths of all nine team roles within the team, and suggests the different roles that each team member should ideally take. The basis on which this prediction is made is not available in any published work.

The question of whether a team is balanced can then be addressed. Different results are likely based upon the definition used. According to Senior [4], who also used the Belbin system to investigate team roles, 'the most straightforward and most used method of determining team balance is to establish whether team members' profiles, collectively, have all nine team roles represented at the natural level'. Alternatively, she suggests that 'a team would definitely be unbalanced where a team role was not represented,

either 'naturally' or at the 'able to be assumed' level.

METHODOLOGY

At the start of the academic year, each student was asked to complete a Self-Perception Inventory and an Observer Assessment Form for each of their friends. Every effort was made to ensure that at least four Observer Assessment Forms were completed for each student. However, it was impossible to collect all the required Observer Assessment data for two of the Mechanical Engineering students and the ERASMUS students. All the data were entered into the software and individual profiles were created for each student.

The students undertaking the Building Project were then placed in teams, ensuring wherever possible that no team was disadvantaged, since the project was an important element of their final year assessments. Based on the project specification it was decided that the optimal team size would be four, but some teams would have to incorporate five students, to avoid a team of three which was seen as too small and teams greater than six which are known to have their share of problems including the need to be well structured, authoritarian led or laissez-faire groups [5]. The team profiles were then created. Although the teams for the Automotive Project and the Transmission Project were created using alternative methods, the team profiles for all the teams were analysed to enable comparisons between all the teams to be made. All the data were withheld from the students, and the associated academic staff, until the project work was completed and marked. This was to ensure that the predicted individual and team profiles did not affect the behaviour of an individual within a team, when undertaking the project work and that there was no risk of the data influencing any academic decision. This strategy meant that the predicted behaviour could be compared with the actual

Table 2. The team roles relevant to the different stages of the team activity

Key Stage of Team Activity	Requirements	Relevant Team Roles
Identifying needs Finding ideas Formulating plans	A strong goal awareness Weighing up the options Making good use of relevant experience and knowledge	Shapers and Co-ordinators Plants and Resource Investigators Monitor Evaluators and Specialists
Making contacts Establishing the organisation	Champions of the plans Plans need to be turned into procedures	Cheer leaders Resource Investigators and Team workers Implementers and Co-ordinators
Following through		Completer Finishers and Implementers

behaviour of the teams. The teams undertaking the various projects had 4, 5, or 6 members, so the size of a team was never an issue.

This comparison was achieved through:

- two different questionnaires—the first, entitled ‘Teamwork Review’, was completed midway through the projects (December) and the second, entitled ‘Team Roles’, was completed two weeks before the end of the projects (April);
- two peer assessments—one after the projects had been running for ten weeks (January), and the other once all the work had been submitted (May); and
- comments received from the three different academic supervisors.

For the ‘Teamwork Review’ questionnaire, all the students were asked to describe their team’s characteristics and secondly to define the roles (in general terms) adopted by each of the team’s members, including themselves.

For the ‘Team Roles’ questionnaire, all the students were given descriptions of each of the nine team roles (and were asked to identify the roles that were applicable to them and all their team-mates on a scale of ‘always’ through to ‘never’. With ‘always’ scoring a maximum of five and ‘never’ scoring one, an overall ranking of the team roles for each team member was determined by calculating the mean score for each role.

For the two peer assessments, the students were simply asked to rank their contribution to the team and that of their team mates on a scale of 5 (high) to 1 (low).

In addition, the balance of each team was investigated at various stages of the study, using

the Self-Perception Data, the Observers’ Data, and the ‘Team Role’ questionnaire data. To ensure comparative data, the Self-Perception data were analysed in terms of a) the preferred roles, b) the preferred and manageable roles, and c) the top three roles. The Observers’ data were analysed in terms of the top three roles, as were the ‘Team Role’ data. The top three roles were chosen for analyses on the basis that if the teams were to distribute all the roles equally amongst themselves, some team members would have to cover three roles. For all the data sets the missing roles were identified, and then compared against the team roles that are relevant to particular stages of the team activity, as defined by Belbin and shown in Table 2.

RESULTS

The Self-Perception Inventory provided information on how the students perceived themselves and a ranked list of their preferred roles, which were further subdivided into the categories of ‘most preferred roles’, ‘manageable roles’ and ‘least preferred roles’. An analysis of each student’s highest and lowest ranked roles showed that most students perceived themselves as specialists and that none of them perceived themselves as team workers (Fig. 1). In fact the role of team worker was definitely seen as the least popular role (Fig. 2). Extending the review to the observers’ assessments showed some striking differences. The most popular role was that of plant, closely followed by the specialist whilst none of the students were seen as

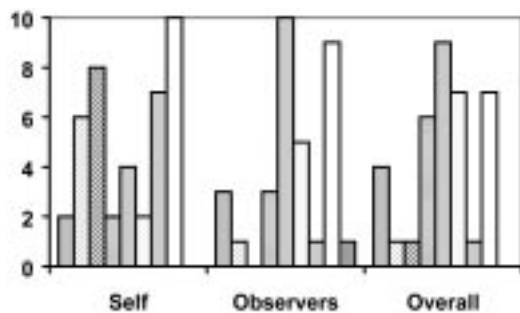


Fig. 1. The highest ranked role.

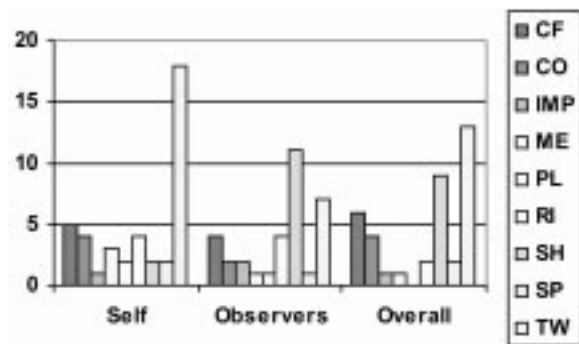


Fig. 2. The lowest ranked role.

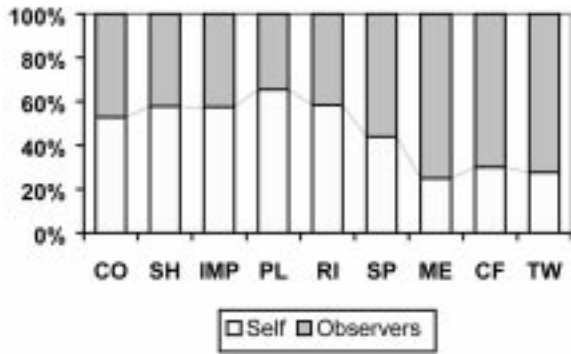


Fig. 3. An example of a good agreement for one student.

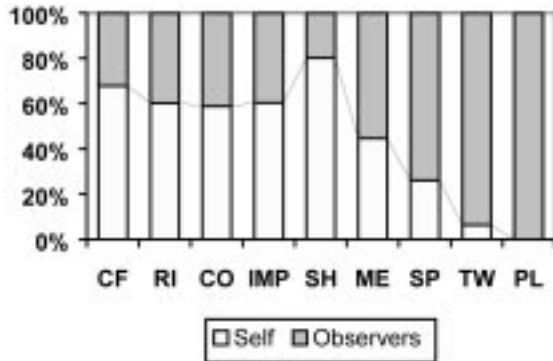


Fig. 4. An example of a bad agreement for one student.

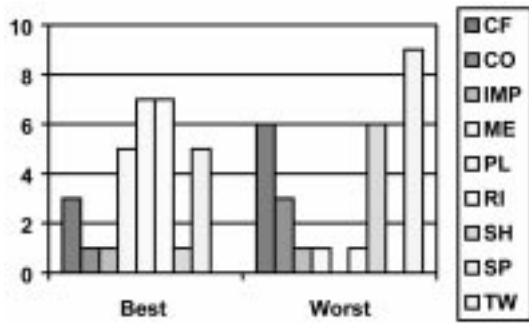


Fig. 5. The best and worst roles for the building project students.

first choice implementers. Considering the least favoured roles, the observers now graded the shaper as the least preferred role, followed by the team worker.

The discrepancy between the self-perception profile and the observers review varied from one student to the next, with fairly good agreement amongst one or two and total disagreement amongst others. Good agreement was defined such that there was an agreement between the most and the least preferred roles (Fig. 3). Bad agreement occurred when the least preferred roles from the self-perception analysis (plant scored 0%) became the most preferred role from the observers' point of view (Fig. 4). The discrepancy between the self-perception results and the observers' analysis has previously been observed in other studies [6–8]. It is likely to be due to the combined effect of the students completing the self-perception form from a wishful perspective (that is, how they would like others to see them) and the observers not knowing their friends as well as they thought. This is not an unusual scenario and Belbin has repeatedly emphasised that the self-perception data and the observers' analysis must be used in conjunction to give an overall picture of an individual [9], and indeed this is the premise on which the GetSet™ software is marketed. This overall assessment once again provides a ranking of the roles from the most preferred to the least preferred roles. Analysis of this overall data reinforced the earlier work, showing that the most preferred role was that of the plant, followed by the specialist and the resource investigator (Fig. 1), whilst the least preferred role was still that of team worker, followed by the shaper (Fig. 2).

Using the overall rankings as a starting point, the most and least preferred roles for each student were identified. It can clearly be seen from Fig. 5 that most students preferred the roles of plant or resource investigator whilst no one liked the role of team worker. Since the first scenario for a balanced

Table 3. The team descriptors

Team/s	Descriptor
Bld-A	... a well-balanced team with a good general spread of personal qualities ...
Auto-C	
Bld-B	... is likely to work to high professional standards and this will be helped by the readiness of the team
Auto-C	members to consult one another ...
Bld-A	... contains people with deep thinking capacity and is likely to feel most motivated when dealing with
Bld-E	intellectually demanding problems ... a formal way of settling arguments
Bld-F	... teams's reputation is likely to rest on its particular specialist knowledge and its capacity for analysis ... It
Auto-A	is as though the team possesses a good steering mechanism, once it gets moving.
Trans-A	
Trans-C	
Bld-G	... well set up to break new ground, ... not easy to achieve unless the distinctive roles and potential
Auto-B	contributions ... are adequately agreed at the outset ...
Auto-D	
Trans-B	
Trans-D	
Bld-C	... an interest in exploring untried possibilities is likely to figure strongly in this team ...
Bld-D	
Trans-E	... possesses the strengths to enable it to do a very professional and thorough job. ... difficulty in seeing
	itself as a team ...

Table 4. Predicted missing roles

Number of missing roles					
0	1	2	3	4	5
Bld-A	Bld-B	Bld-F	Trans-A	Auto-D*	Bld-G
Bld-C	Bld-D	Trans-C	Trans-E		
	Bld-E		Auto-B*		
	Trans-B				
	Trans-D				
	Auto-A*				
	Auto-C*				

* Based on Self-Perception data only.

team was that all roles would be represented in a team within the preferred roles of each team member, it was apparent that teams could never be balanced on this descriptor since the team-worker role was so unpopular. However the teams still had to be defined. Based on the required team size, different combinations of students were placed together on the hypothesis that since students would have to undertake two or three roles if the team was to be balanced, the combination of their top three roles should yield the required balance. It proved impossible to balance all the teams on this premise so the final teams were selected based on the predicted team profile as shown in Table 3. Analysis of the balance of the final teams shows that only two teams were fully balance (Table 4), and based on the team roles which are relevant at different stages of the team activity (Table 2), only one team may have any problems. Team Bld-G may find it difficult to 'identify the needs' and 'make contacts'. Analysis of the students preferred plus manageable roles, as predicted from the Self-Perception Data showed that all the teams would be balanced since all nine roles would be covered by at least one team member.

The teams undertaking the Automotive Project and the Transmission Project were assessed in a similar way. However, due to the problems in obtaining Observer data for the ERASMUS students, it was impossible to obtain an overall assessment for these students and the analysis had to be based on the Self-Perception Data. The team descriptors (Table 3) would indicate that only one team would have any difficulty in seeing itself as a team (*Trans-A*). However analysis of the balance of the teams showed that none of the teams were fully balanced (Table 4) and correlation with the team descriptor (Table 2) showed that five teams may have problems: teams Bld-G and Trans-E would have difficulty 'identifying the needs', teams Bld-G, Auto-D and Trans-C would have difficulty 'making contacts', and team Auto-B would have difficulty 'establishing the organisation'. However, once again analysis of the students preferred plus manageable roles, as predicted from the Self-Perception Data showed that all the teams would be balanced.

All this initial work predicted the behaviour of

each team and identified the teams with potential problems. The next stage of the work assessed the actual teams' behaviour to finally enable the predicted and actual team behaviour to be compared.

The results of the teamwork review showed that, at this relatively early stage of the projects, the teams were still establishing themselves. Some of the teams felt that initial progress was slower than expected, though the teams were slowly 'gelling', and this was particularly true for staff defined teams (Buildings and Transmission projects). In addition, some of the teams were still working as a group of individuals rather than a cohesive team with some students describing their teams as not co-ordinated, fragmented (to various extents), not well focused, split, etc. In fact two team members specifically commented that their teams were not working as a team. Conflicting responses were also received from different team members, for example one student describing the team as co-ordinated whilst two other team members described it as not co-ordinated.

The second part of the Teamwork review aimed to establish if any students were in fact filling the specific roles predicted for them by the GetSet™ software. The results showed that a few of the students had naturally taken up the expected roles. For example one student was described by their team-mates as 'the team organiser' whilst GetSet™ predicted that the same student 'should be appointed the organiser'. As a second example one student, in a different team, was described by their team-mates as 'Steers discussion towards a realistic solution' whilst GetSet™ predicted that the same student 'would be the person best suited to ensuring that talk is turned into a worthwhile action'.

The first quantifiable evidence of team behaviour arose from the Peer Review Assessment which identified if any students were not contributing to the team. The results showed that most of the teams (5/7 Buildings teams, 2/4 Formula student teams and 2/5 Transmission teams) had no identifiable problems with all team members rated as four or five, four teams had potential problems with at least one student scoring three. However, three teams, (Bld-E, Auto-D and Trans-B), had problems with at least one student scoring less than

Table 5. Actual missing roles

Number of Missing roles					
0	1	2	3	4	5
Bld-B	Bld-C	Bld-A	Bld-F	Trans-E	
Trans-B	Bld-G	Bld-D	Trans-A	Auto-A	
	Auto-C	Bld-E	Auto-D	Auto-B	
		Trans-C			
		Trans-D			

three. The second peer review provided information on the teams' development. Only six teams now had no identifiable problems (4 Building Teams, 1 Formula student team and 1 transmission team), four had potential problems and the remaining six had problems. The movement between the categories was two way with some teams showing an improved team performance whilst others clearly showed signs of deep division.

The final aspect of this study involved the analysis of the 'Team Roles' Questionnaire. Since the results ranked the team roles for each student, it was possible to determine whether the students adapted their profiles to the different team requirements and secondly to determine the actual team profile, based on the top three roles for each team member. The results showed that 3 students showed no variation in their role profile with the different teams, 11/33 agreed on their best role, 8/33 agreed on their worst role and 16/33 did not agree on either role.

The balance of each team was then determined from the top three roles for each of the team members. The results showed that only two teams were fully balanced (Table 5) and correlation with the team descriptors (Table 2) showed that four teams would have problems 'Identifying Needs' (Bld-A, Trans-D, Trans-E and Auto-D); one team would have problems 'Finding Ideas' (Trans-E); two teams would have difficulty 'Formulating Plans' (Trans-A, Auto-A) and one team would have difficulty 'Establishing the Organisation' (Auto-B).

Correlation between the predicted and actual team performance (Table 6) showed agreement in seven of the teams. That is, no problems were predicted in 3/7 Buildings teams or 1 Formula student team and none occurred during the projects as observed from the actual team performance or peer reviews data and problems were predicted in three teams and this was born out with

the peer reviews and/or the actual team performance. Two teams were predicted to have problems but no problems were observed through the project. In contrast six teams were predicted not to have any problems but problems arose throughout the project as was evident by either the peer reviews or the actual team performance.

In addition, four out of the five teams which were described as 'well set up to break new ground . . . not easy to achieve unless the distinctive roles and potential contributions . . . are adequately agreed at the outset' had definite problems throughout the course of the projects (shaded boxes in Table 6).

DISCUSSION

The need to build effective teams has been widely recognised [5–17] and numerous tips are available to try and achieve it. Some studies have identified various characteristics of good effective teams [10, 15, 16]. They can be summarised as 'commitment, trust and support for one another'. There is no dispute about these characteristics, only in how they can best be achieved within a team.

This study used the Belbin technique to try and establish effective balanced teams. The validity of this technique has been questioned by some researchers [6, 8, 18], positively supported by others [4, 14, 19–21] or utilised in numerous studies including those reported by Fisher *et al.* [22] and Blignaut and Venter amongst others. The results of the study have shown that the GetSet™ software, although easy to use, requires accurate data to be collated if the predictions are going to be valid. Numerous problems can arise when using this in class teaching since the assumptions that (1) each student has four good peers who know them well within the cohort and that (2) the students'

Table 6. Comparison of predicted and actual performance

	Team						
	A	B	C	D	E	F	G
Buildings	A				1, 2	2	P
Formula Student	A	P A 2		P A 1, 2	-/-	-/-	-/-
Transmission	A	1, 2	P	A 2	P A	-/-	-/-

P = Predicted performance; A = Actual team performance; 1 = First peer review; 2 = Second Peer Review -/- no team

responses are honest and unbiased cannot always be guaranteed.

Placing all the students in balanced teams was a difficult job, since no team should ideally have been disadvantaged or handicapped in its expected performance since the projects formed a significant element of the academic studies. It was also assumed that all the students would fully partake in the project work and that no student had specialist knowledge in the project area, outside that covered within the degree scheme. For this particular cohort of students, neither assumption proved to be valid. The peer review data identified the students which were not pulling their weight, though interestingly the teams most effected by this were not the Building Teams, suggesting that the use of the Belbin technique had led to better teams. The inclusion of a team member with specialist knowledge provided that team with additional resources that meant the team's overall performance was better than predicted.

The strongest correlation between predicted behaviour and actual behaviour arose for the teams that were described as '... well set up to break new ground ... not easy to achieve unless the distinctive roles and potential contributions ... are adequately agreed at the outset ...', as indicated by the shaded boxes in Table 6. The inability of three of these teams to perform well, as indicated by the correlation between the predicted and actual performance would suggest that, with the current structure of the projects, these teams are being disadvantaged, and in future, such teams should not be blindly created. That is, in future, if this team descriptor is used, each student must be fully aware of their strengths and weaknesses and the teams would need to be closely monitored to ensure any problems are resolved as they arise. The need to advise and support teams, in terms of potential problems identified from the team descriptor is strengthened when looking at the performance of the remaining teams. All but teams Bld-B, Bld-C, Bld-D and Auto-C experienced some problems through the projects. The common aspect of all these teams was their positive attitude whereas the other teams had difficulty seeing themselves as a team (Trans-E), needed a formal way of settling an argument (Bld-A and Bld-E) or were slow to get moving (Bld-F, Auto-A, Trans-A and Trans-C).

The need to inform students about team roles and their interactions was strongly advocated by

Adams [23] who concluded that 'if teams are to be successful, students must receive adequate training on issues related to forming and maintaining teams'. However, the extent of team training that is required is unknown, and based on the results obtained, the extent and depth of training may need to be tailored for each different team descriptor. At present, all the teams in this study received formal tuition on this subject, centred round the four topics of:

- teams and groups' dynamics and needs;
- forming teams;
- effective and ineffective teams;
- the manager's role within the team.

As part of this study the students were purposely not informed about Belbin's work and specifically their identified roles and team characteristics. The rationale behind this was the desire to ensure that firstly, the students behaved naturally and did not try and emulate their descriptions, making it difficult to access their accuracy, and secondly that the direction the team took was not influenced by its description. In view of the results obtained, it is clear that some of the teams, depending on their descriptor, need appropriate guidance and support.

CONCLUSIONS

The difference between a group and a team lies in the interrelationships between their members. This study aimed to identify the characteristics of each individual within the team and the team as a whole using the readily available GetSet™ software. The results showed that although all the teams could be identified as balanced, the characteristics, development and function of the teams varied considerably. In addition, the study has identified the need to ensure all the team members are fully aware of the strengths and weaknesses of the team and of the individual members in order to maximise the team's effectiveness, address any ongoing issues and problems and fulfil the team's potential.

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