Group Dynamics and Software Engineering

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Abstract

This paper reports on an experiment that was conducted to determine the extent to which group dynamics influences the effectiveness of software development teams. The experiment was conducted on software engineering project students at the Queensland University of Technology (QUT).

Introduction

Group projects are a well established method for introducing students to some of the issues involved in programming in the large [Tomayko87]. One of the key learning experiences for students in group projects is the extent of group interaction that takes place in building large software systems. The fields of psychology, sociology and management have considered team building and personality types and how people work together for some time. Some of this has been carried over to software engineering. The two most commonly considered items are the three core personality types (task-oriented, self-oriented, and interaction-oriented) [Bass63] and the Myers'-Briggs' personality profile [Myers98]. This paper reports on an experiment that considers a lessor known sociological profile, Belbin's Team Roles profile [Belbin81].

The remainder of this paper will provide a brief summary of Belbin's Team Roles. It will also describe the experiment and its results and explain conclusions reached so far and provide directions for future work.

Belbin's Team Roles

Following several years of observations of organisations and management teams, Dr. Meredith Belbin developed a profile that describes nine roles that people play within a team. His observation was that teams that succeeded were those teams that had a good balance of people playing all roles within the team. Teams without all the roles, or a poor balance of roles, usually failed. He and his research team have successfully predicted the success and failure of a large number of teams based solely on the distribution of the team roles within the teams. Dr. Belbin's research also shows how teams without a good balance of roles can still take advantage of the roles to help improve the group dynamics within a team. Dr. Belbin has also developed a "self-perception inventory" which is a simple test that people can take to determine what roles they tend to play within a team situation [Belbin81].

The nine team roles are plant, resource investigator, co-ordinator, shaper, monitor evaluator, team worker, implementer, completer, and specialist. The last role, specialist, is unique in that it does not contribute directly to the team's group dynamics. An important point is that these roles are completely separate from the technical contribution that people make to a team. (For example, a person may be on a team because they are involved in implementing the decisions made within the team, but they may play the Belbin team role of resource

investigator.) Each of the team roles will be described in the following paragraphs.

"The **Co-ordinator** (alternatively titled Chairman) provides leadership by co-ordinating the efforts and contributions of the team members. … This is often a fairly subtle form of leadership which consists of encouraging contributions from others [Belbin81]." In other words this is the type of person who displays good leadership qualities that make them a good chairperson. It is important to note that this is a "personality type" or a role that someone naturally plays, it is best if this person is also the formal leader of a team but they can still play this role if they are not the formal leader.

The **Shaper** (alternatively titled Driver) provides leadership by directing and controlling team members. This type of person exerts a strong influence on how the team operates [Belbin81]. This type of person tends to push a team towards its goals. They are good at getting things done, but can overwhelm other team members. Again, this person may not be the actual formal leader of a team but without diplomacy their characteristics can alienate the formal leader.

The **Completer** (alternatively titled Finisher) is the type of person who pays close attention to detail and follows-up on un-finished tasks. They tend to generate a sense of urgency within a team and are good at keeping a team on schedule [Belbin81].

The **Implementer** (alternatively titled Company Worker) is good at accomplishing detailed and practical outcomes. They can be trusted with the responsibility of implementing group decisions [Belbin81]. They are good at taking ideas and plans and turning them into practical procedures.

The **Monitor-Evaluator** is good at evaluating ideas and suggestions [Belbin81]. They tend to be objective and good at analysing problems and evaluating alter-natives. They are commonly referred to as the 'devil's advocate'. It is important for this type of person to use tact when pointing out problems and not to be overly critical of the suggestions of others.

The **Plant** (alternatively titled Originator) is the 'ideas person' of the team. They are good at generating ideas to deal with problems confronting the team. They tend to work best when focusing on major issues, rather than fine details [Belbin81].

The **Resource Investigator** acts as a source of information and ideas. They are good at developing contacts with people outside of the team who may be useful to the team [Belbin81]. They usually have a set of contacts and are continually expanding that set. They will usually make use of their contacts without prompting from the team.

The **Team Worker** (alternatively titled Supporter) helps to maintain group harmony and team spirit. They are good at improving communication within a team and drawing people in to discussions [Belbin81]. This is an important role within a team but because a lot of their work takes place in the background it is easy to not appreciate the value of these people.

The **Specialist** provides knowledge or skills that are in rare supply. In commercial settings they tend not to be full team members; they are more often brought in to deal with specific issues or problems [Belbin81]. This is not so much a personality type as a role a person can play within a team. The specialist role does not affect the group dynamics of a team directly. Thus a team can work successfully without a specialist. There are personality traits and actions associated with a specialist, which allows Belbin to identify this type of person in his profile test. A specialist tends to be

single-minded and independent, qualities that allow them to gain their special skills.

Belbin's research indicates that all roles, except the specialist, are needed in successful teams. Care needs to be taken regarding the co-ordinator and shaper roles. Both of these roles are leadership roles so their formal positions within the team need to be well defined. The people who play these roles need to work closely together to ensure the team does not split into factions. To avoid leadership disputes it is best to have only a single co-ordinator and shaper in a team. In some situations it may be best to have only a co-ordinator or a shaper and not both, if the available people who play these roles are likely to cause conflict if on the same team. It is most advantageous to have multiple implementers and team workers in a team.

Most people have a primary role that they play in a team situation and two or three secondary roles. A role may be filled by someone who has that as a secondary role, rather than as a primary role. It is possible for one person to play multiple roles within a team. This allows small teams to be created that are still well balanced with respect to Belbin's team roles.

In situations where a team does not have a good mix of team roles it is still possible to make use of the roles. Belbin claims that knowledge of the roles within a team and which roles are missing can allow the team to fill-in the missing roles [Belbin81]. This is done by one or more people playing the role by following the description provided by Belbin.

Experiment

The experiment involved students taking their first software engineering project at QUT. The project is the major assessment item in the subject Software Engineering Principles [Thomas95]. Students in this subject are in their full-time equivalent of second semester of second year of a three-year degree (equivalent to juniors at a North American university). Students work in groups of four or five on a single project for thirteen weeks. They cover all phases of development from requirements analysis to design to implementation and testing to initial release.

The goal of the experiment was to validate Dr. Belbin's research and see how applicable it was to software development teams. The hope was that Dr. Belbin's team roles would provide a simple tool to aid team members to understand each other's perspectives and improve how they work together.

The experiment was conducted on two cohorts of students over two years. Both cohorts were similar in size and were made up of students with similar backgrounds. Both cohorts worked on the same project. The first cohort was the control cohort and students were placed into groups in a pseudo-random fashion. (Pseudo-random in this case means that friends, and people who knew others, tended to stick together and others were randomly placed in groups.) The second cohort of students was allocated to groups according to their Belbin team role profile. These groups were put together so that all groups had a good mix of team roles.

The project on which both groups worked was to implement a local web spider. This program takes an HTML file as input and scans the file for links to other documents. The program then recursively scans the linked documents for further links. The program then prints the HTML code for each document. Only links to files on the local file system were to be processed.

The first cohort of students consisted of 109 students, 4 of whom where part-time students and the remaining 105 were full-time students. They were divided into twenty-four groups consisting of either four or five students. The first cohort was made

up of twenty-nine students undertaking a double degree in Electronics Engineering and Computing Science, seven students undertaking a double degree in Mathematics and Computing Science, and seventy-three students undertaking a Computing Science degree. The second cohort consisted of 163 students, 5 of whom where part-time students and the remaining 158 were full-time students. Six of these students did not undertake the Belbin team role profile test. These six students were randomly allocated to existing teams of four students who were already well balanced. The second cohort was divided into thirty-six groups of either four or five students. The second cohort was made up of twenty-eight students undertaking a double degree in Electronics Engineering and Computing Science, fourteen students undertaking a double degree in Mathematics and Computing Science, three students undertaking a double degree in Secondary Education and Computing Science, and one hundred and eighteen students undertaking a Computing Science degree. In both cohorts each group met with a tutor for twenty minutes each week. The tutor was to act as customer and provide guidance for the project.

A number of issues were identified as potential problems that could influence the study and the interpretation of the results. The first issue is the limited number of people who played some of the roles. Table 1 below shows the numbers and percent of people in the second cohort who played each of the roles. Of the 157 students who did the Belbin profile test a small number scored an equal high mark on two roles, they were counted as playing both roles as their primary role. The percent column is the percentage of people in the cohort that played each role as either a primary or secondary role. As can be seen from table 1 there were only a small number of people who played the roles of plant, monitor evaluator, co-ordinator, and resource investigator. (This result is similar to findings from Myers'-Briggs' Type Indicator (MBTI) testing of information technology professionals. More than a third of information technology professionals fall within two of the sixteen Myers'-Briggs' types [Teague98].) Fortunately, between the shapers and co-ordinators, there were enough people to provide leaders for every team. The plants and monitor evaluators were spread as best as possible between teams. All teams had someone playing at least one of these roles. Those teams that did not have someone in both roles were told of their lack and their tutor tried to get them to compensate for this role. Due to the small number of resource investigators many teams were missing this role. This subject has a number of resources that are provided to students, so the lack of a resource investigator was not considered as significant a problem as it could have been. Teams were again notified that they were missing this role and that they were to compensate for it. To help groups to compensate students were reminded in lectures of the resources that were available.

Roles	Primary	Secondary	Total	Percent
Implementer	26	47	73	46.8%
Specialist	42	29	71	45.5%
Team Worker	30	29	59	37.8%
Completer	18	34	52	33.3%
Shaper	14	26	40	25.6%
Plant	10	18	27	17.3%
Monitor Evaluator	10	15	25	16.0%
Co-ordinator	10	13	23	14.7%
Resource Investigator	4	10	14	9.0%

Table 1 – Number of People Playing Roles

Another issue is the number of profile tests that were completed incorrectly. The test

consists of seven sections, each containing ten statements. Respondents are to allocate ten points across the statements in each section, depending on how they think the statements match their actions. Thus each respondent should allocate seventy points on the test. In the second cohort of students, thirty-one percent had totals above or below seventy points. About half of these students (15.4 percent of the cohort) were within two points of seventy. Seven percent of the cohort had totals that were more than five points above or below seventy. As their totals were not widely different from seventy it was assumed that it was a case of simple arithmetic errors by the students and that their results were essentially correct. Only two students (1.3 percent) had totals that were more than ten points below seventy. One of these showed a clear trend towards two roles, so was judged as playing those roles. The other only allocated fifty-three points and did not show any clear trend for any role. This student's score was not used for team allocation. To help eliminate incorrect scoring a web based version of the test has been developed. This will be used in July 1999. This could lead to more students not taking the test, but they will be frequently reminded to do so. (Please contact the author of this paper if you would like access to the web based test.)

A related, and possibly more serious, issue is the number of profile tests that had high drop points. Belbin's profile test contains a number of general statements that are used to catch people who are unclear of how they act within a group situation. The points allocated to these general statements are called "drop points". Dr. Belbin suggests that if someone scores more than seven drop points that they should take the test again. In the second cohort of students seventeen percent had more than seven drop points. (Five percent had more than ten drop points.) The high percentage that seem unclear of how they act in group situations is not unexpected. About forty percent of the cohort would be young students who had only graduated from secondary school eighteen months before taking this subject. Some of the other students are likely to have had limited exposure to formal group work. Given the time constraints of forming teams and getting students started on the project, little was done about this problem. It was assumed that the scores provided were the best indication available of the roles they were likely to play in a group. Students were encouraged to retake the profile test at the end of semester, to see if their experiences modified their responses. (Unfortunately, this was not done formally, so no record is available of these retests.)

Another issue is that this is a student project where students are not working within a formal company structure with clearly defined positions and responsibilities. It may be argued that Belbin's team roles, while representing personality characteristics, relies on people understanding their work relationships. The counter-argument to this is that Dr. Belbin's original research was conducted on graduate student project teams at Cambridge University. These teams are likely to have had similar problems of having no formal company structure. (It should be noted that his research findings have been verified in a number of commercial organisations in the United Kingdom and Australia.)

The final issue is also related to the experiment being conducted on students. Students are working under different constraints and priorities than team members on a commercial project. This is only of concern if these results are to be used to justify action in a commercial organisation. As this report is being presented at an educators' symposium this issue will not be dealt with.

Results

The results of the experiment were not as clear as had been hoped. Students in the second cohort, who were placed into teams that were predicted to be successful according to Dr. Belbin's team roles, did not do significantly better than the students in the control cohort. One subjective observation was that groups in the second cohort seemed to work more smoothly than groups in previous semesters.

Marks are allocated to groups rather than individuals. For the first cohort the minimum mark was 51%, the maximum mark was 97.5%, and the average mark was 79.5%. For the second cohort the minimum mark was 56%, the maximum mark was 95.5%, and the average mark was 81%. These are summarised in chart 1 below. As can be seen there is very little difference in the assessed result of the project between the two cohorts of students.

The only noticeable difference is when ranges of marks are compared, and the differences are not statistically significant. The first cohort had 13.75% and the second cohort had 8.5% of students in the range of marks from 50% to 64%. The first cohort had 10% and the second cohort had 11% of students in the range of marks from 65% to 74%. The first cohort had 34% and the second cohort had 38.65% of students in the range of marks from 75% to 84%. The first cohort had 40.3% and the second cohort had 41.7% of students in the range of marks from 85% to 100%. These are summarised in chart 1 below. The chart shows there is a noticeable shift of students into the middle grade ranges from the bottom grade range, but as the shift is of only about 5.5% of the students in the subject it is not significant.

Conclusion

Dr. Belbin's team roles do not seem to predict success and failure as well with student software engineering project groups as his research indicates for management

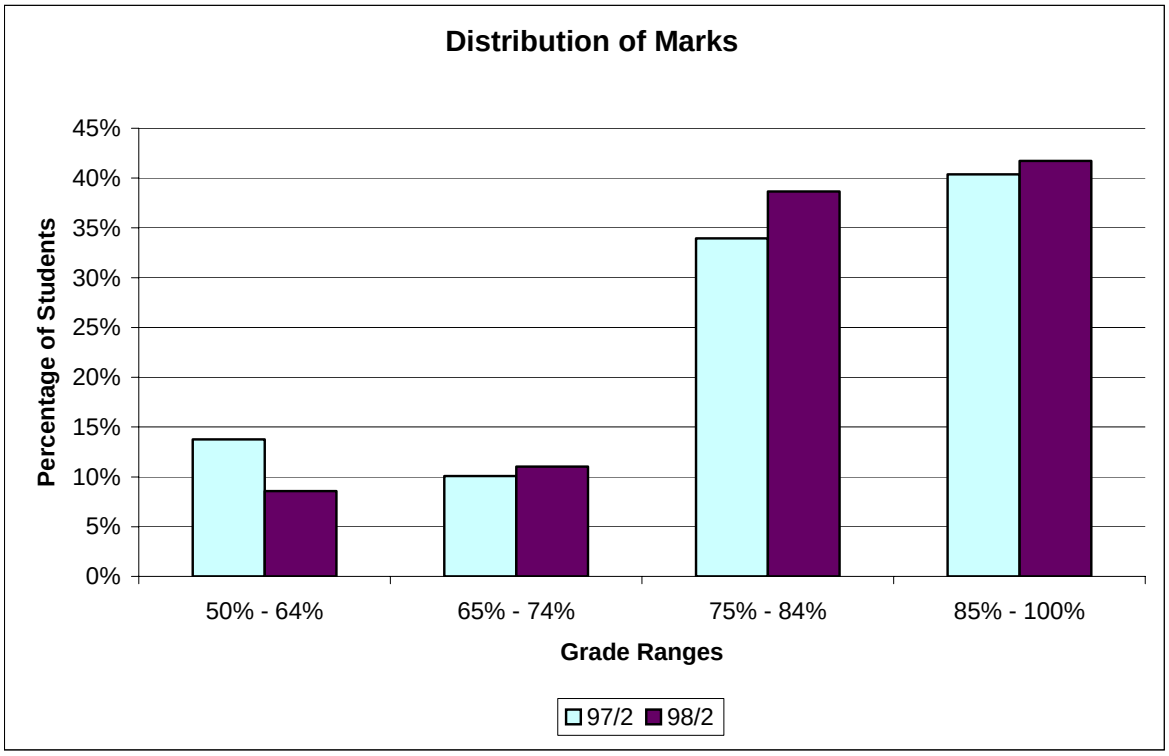

Chart 1 – Distribution of Project Marks

teams. In the experiment reported on above there was only a small improvement in the marks students achieved in their projects. There are a number of possible reasons for this seeming failure.

One possible reason for the seeming failure was that the students in the first cohort formed their groups on their own, rather than being randomly assigned to groups. This means that the majority of groups in the first cohort were formed from groups of friends, or at least from groups of students that knew each other prior to the start of the project. It is possible that groups of students that associate with each other or who are friends may already be well balanced in terms of Belbin's team roles. It is also possible that friendships mitigate the impact of Belbin's team roles. Friends are more likely to be tolerant of each other's differences. Friends are also likely to have established their own group dynamic processes in how they relate to each other. A future experiment could have groups of friends take the Belbin profile test and see how well the team roles are distributed amongst the group of friends. While on this point it should be noted that tutors in this subject have commented in the past that they have seen friendships end because of how the friends interacted within the group project.

One important thing to consider is the standard success rate of student project groups in the subject Software Engineering Principles. If success is measured by groups successfully completing their projects and achieving a mark greater than fifty percent, where the majority of the mark is based on the quality of their software engineering process, then the vast majority of groups always are successful in this subject. The marks indicated for the first cohort are the usual ranges and average marks for the subject. This indicates that Dr. Belbin's team roles may contribute to team success but there are many other factors that also contribute to team success in a student software engineering project.

Some students from the second cohort informally commented that they tended to use the team roles at group meetings at the start of the project. Many, though not all students, commented that they did find that the roles seemed natural. They also commented that group members continued to play the roles later in the project, even when time pressures meant that groups did not consciously try to make use of the roles.

More research needs to be conducted to see if Belbin's team roles can be used to significantly improve group dynamics within software engineering project teams. Informal comments from students seem to indicate that knowledge of the team roles does improve their awareness of how others work in team situations, and that this knowledge makes them more tolerant of how different people react in teams.

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