

# A Study of the Effect of Disruptions on the Performance of Software Engineering Teams

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## Abstract

*This paper describes ethnographic observations and analysis of the performance of student teams working on year-long software projects for industrial clients. Personality types were measured using an online version of the Myers Briggs Type Indicator (MBTI), as a basis for studying how individuals interacted within the teams, and the effects of disruptive issues on the quality of work produced by the teams. Aspects recorded included the effect of personality type on behavior towards team mates and how this related to the amount of disruption, and the numbers of positive ideas brought forward from each member. A significant finding was that issues which teams did not discuss adequately caused more problems for the quality of work than issues which produced actual disruption within the team.*

## Keywords

Jungian Personality Types, Myers-Briggs Type Indicator, Group Work in Software Engineering, Ethnographic Observations.

## 1. Introduction

It is widely accepted that the social factors affecting the performance of teams working in software engineering (SE) projects are as important as the technical aspects e.g. Curtis [1]. Two main approaches have emerged to study the effects of such factors on the performance of teams. One of these approaches is concerned primarily with the various roles that individuals play within a team. These roles were first identified by Belbin [2], and then ways in which they apply to SE teams have been investigated by Henry and Stevens [3].

The other approach has focused on the kind of interactions that occur between the individuals within an SE team, and in particular with the way in which this is influenced by the interplay of different personality types. Thus Bostrom and Kaiser [4] and Elam and Walz [5] observed the effects of interpersonal conflicts within a team working during the design phase of a software development project. Teague [6] and Capretz [7] have argued that a variety of personality types are needed in the modern SE industry, while Rutherford [8] has compared teams that were homogeneous and heterogeneous in terms of their personality profile.

Also the present authors have studied the impact of different personality types on SE teams [9], [10]. The work reported here builds on these earlier studies by examining the actual effects of disruptions within teams, and in particular how they affected both the cohesiveness of the teams and then the quality of the work they produced. SE teams are particularly good subjects for such study in comparison to teams in other contexts as they are engaged in highly structured tasks that have measurable outcomes. Thus, a well performing SE team would not just work in an observably efficient and cordial manner. They would also deliver products and do so within the agreed time scales.

For this study, qualitative measurements of product quality were not feasible, and instead the focus was on the actual mechanisms by which it might be affected. The initial expectations were that issues which caused the most disruption should also do the most damage to the quality of the work produced. What became apparent, though, was that the failure of a team to debate an issue adequately could actually do more damage than if a debate had resulted in serious disruption.

The context for this study is the Software Engineering Observatory at the University of Sheffield. The observatory is built around three

projects (Genesys, Maxi and Software Hut) undertaken by different groups of students.

The structure of the rest of this paper is as follows. Section 2 gives a description of the relevant personality research; section 3 describes the research methods used, section 4 explains how the observed behavior was classified and analyzed, section 5 summarizes the main results for the teams studied, section 6 aggregates these results, section 7 discusses the findings of this research in both the current and historical context, and finally section 8 draws conclusions from the work done and proposes future work.

## 2. Personality Research

The theory underlying this research is provided by the work of Jung [11], as developed by Myers-Briggs [12] in designing the MBTI (Myers-Briggs Type Indicator), and applied to SE development teams as described in [9], [10]. The MBTI is widely used to assess an individual's personality style on four dimensions: social interaction, information gathering, decision making, and dealing with the external world.

The official MBTI is a paper-based inventory that uses a self-report format, with 94 forced-choice items to cover the four bipolar discontinuous scales implied in Jung's theory: introversion-extraversion, sensation-intuition, thinking-feeling and judging-perceiving. Respondents are classified into one of 16 personality types based on the largest score obtained for each bipolar scale, so someone scoring higher on extraversion than introversion, intuition than sensing, thinking than feeling and judging than perceiving would be classified as an Extraverted Intuitive Thinking Judging type. This classification does not, though, make any sort of judgment as to whether a person is psychologically healthy or unhealthy.

The test also scores the clarity of preference for each function and attitude: e.g. I 52% N33% T22% J62%. An indicator for clarity of preference is:

- 40 % or Higher (30 for T/F) - Very clear preference.
- 31-39 % (21-29 T/F) - Clear preference.
- 11-20 % - Moderate Preference.
- 1-10 % -Slight Preference.

The test used in this research is not the official paper version of the MBTI, but an online test based on the MBTI developed by Human Metrics, a consortium of Israeli psychologists [13], who claim they have found no significant statistical differences between this test and the official paper version of the MBTI.

An alternative personality test is the NEO-PI model, which is based on the five factor model of trait

personality [14]. This model is popular in academic circles and differs from the MBTI in the sense that it seeks to measure traits as opposed to types. Furnham [15] believes that both models would benefit by examining the behavioral and cognitive correlates of their various dimensions, but this is outside the scope of this paper. Since there was no online version of this test, it was not appropriate for use in this study

## 3. Research Methods

Ethnographic methods were employed to observe selected student teams. In order to gain an in-depth understanding of the user culture (in this context SE teams), the authors observed and inquired about the research subjects' normal activities throughout their specific projects.

An important aspect of this process was that of anonymising results. To ensure complete anonymity of subjects each person was given a randomly generated number within each team, such as A1 and B2 and these were used throughout the field notes and for publication of the results.

The subjects showed a high level of acceptance of the observations. In particular there was a high level of cooperation from students when it came to informing researchers about meetings taking place, even where these were outside the University of Sheffield campus.

## 4. Classifications

### 4.1 Ordinal Ratings

There were several analysis phases involved in going from the field notes stage to quantifiable data. These phases are described in detail in [16].

**Table 1: Level of disruption**

Level	Kind of Disruption
1	Premise uncritically accepted with no interaction between team members
2	Dealt with smoothly and harmoniously after a brief discussion
3	Lengthy period of constructive debate discussing the virtues of an issue
4	Caused slight disruption by forcing people off relevant issues
5	Lengthy period of destructive debate, lengthy disruption
6	Caused complete disruption to the work of the team

Previously [9] [10] the authors had created an ordinal scale to measure what is now called the ‘level of disruption’, and this is shown in table 1. It is also necessary to identify what kind of issue an idea, question or problem is related to, and in the earlier work the following scheme was developed for this:

- PSI- Project Specific Issue
- MSI- Methodology Specific Issue
- GSEI- General Software Engineering Issue
- THF- Team Human Factors
- C- Client
- M- Manager

This scheme was used for this study too.

## 4.2 Effects of Disruption

Issues where the level of disruption was rated as 2 or 3 were assumed to be handled ‘normally’ i.e. without disruption, whereas others were expected to have some impact on the quality of the work produced. It was observed that there were two kinds of effects: an internal impact where the relevant issues were resolved without management intervention and an external impact when management was forced to intervene. To measure the extent of these effects two ordinal scales were created, one each for internal and external impacts as shown in tables 2 and 3.

**Table 2: Internal impact of issue**

Level	Internal Impact
0	No Impact
1	Small changes made to document
2	Large scale restructuring to one document
3	Major restructuring to more than one document
4	Complete re-write of documentation
5	No working system at end of project

**Table 3: External impact of issue**

Level	Managerial Involvement
0	No Impact
1	Management intervention led to small changes
2	Major large scale restructuring due to management criticism
3	Large scale restructuring to several documents
4	Marks lost for area of project
5	Deadlines missed, marks lost for late work

Five teams were observed in the study, but due to space constraints only three will be described in this paper: one Maxi (team 2) and two Genesys teams (2 and 4). Full details for all teams are given in [16].

## 5. Results

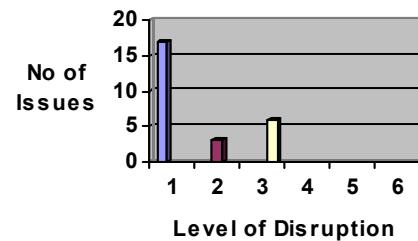
### 5.1 Maxi Team 2

At first glance Figure 1 looks very impressive, showing a team who have managed to go through an entire SE project without any disruptions. Whilst this is true, they were dogged by problems of another nature: the fact that so many issues were not debated meant that on numerous occasions team members were actually moving in opposite directions without any knowledge of what others in the team were doing.

**Table 4: MBTI types Maxi Team 2**

ID	Type	E-I	S-N	T-F	J-P
B1	ENTP	E 1	N 44	T 22	P 78
B2	INFJ	I 56	N 33	F 22	J 33
B3	INTJ	I 61	N 44	T 11	J 11
B4	INTP	I 56	N 22	T 44	P 66

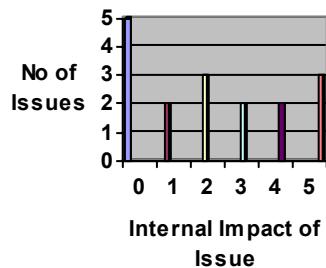
As shown in table 4, there were three NT’s out of four people in this group, a typical profile for engineers. Such people are pioneering and innovative by nature, providing trenchant communication channels remain unimpeded. One reason for the dearth of conducive debate was the teams’ very clear preference for introversion, thinking and intuition. Only one member of the team, B1 had a slight preference for extraversion. Introverted intuitives find self-expression difficult, according to Myers “Even when well balanced, they have a tendency to ignore the views or feelings of other people” [12, page 112].



**Figure 1: Levels of disruption for all issues Maxi Team 2**

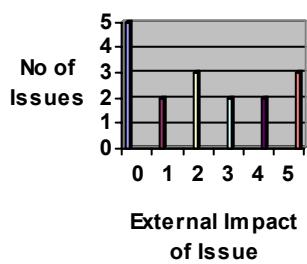
Figures 2 and 3 show that issues without debate were very problematic for this team. The problem was even greater when the manager was involved and

issues became external. Some examples include project risks. They were not seen as a major issue by the team, as a result an important part of the feasibility report was missing.



**Figure 2: Internal impacts of issues  
Maxi Team 2**

Another serious problem was the feasibility study and budget plans. The budget was not drawn up correctly; there was conflicting information from the team with regards to the feasibility study, and as a unit they failed to take heed of the managers' advice. As a result of this the entire stage 1 budget had to be redone, because the manager said it was disorganized.



**Figure 3: External impact of issues  
Maxi Team 2**

The main problem was always a lack of discussion, and when things were discussed they were invariably left open ended with no concrete decision being made. A recurring problem was that information was being put under the wrong heading and on occasions the team had even missed out the specified headings that were prescribed by the manager. In the eyes of the manager this was down to lack of concentration and bad communication between members of the team as they had missed out things when it had clearly been specified that they should be in the report.

In terms of informing and conveying information to their team mates, one member was clearly dominant. B1 was an ENTP, original, individual, independent but

also very perceptive of the views of others. This is one of the reasons why there was no disruption in the team. But because of the clear preference for perceiving there was a distinct lack of any debate that might lead to quick judgments of the situation. Someone with such a clear preference for perceiving like B1 will not come to a conclusion until they have to, and sometimes not even then. Therefore it proved to be very difficult for this team to decide anything, because in many cases they simply did not want to do so.

Another problem that the team failed to discuss was the large burden on the only native English speaker when it came to writing documentation. B1 had to carry on checking documents and do most of the talking in meetings; this was a very heavy load for one person. There was little discussion during the analysis and design stages and this did not go unnoticed, the manager was not too pleased with this situation whereby one member was ostensibly overloaded with documentation. The overall quality of the team process was seriously compromised by the fact that this Maxi team did not work as an effective unit; this was also noted by the manager.

Despite working hard to meet deadlines, the overall team performance was decidedly average due to the fact that they were not working and communicating as a team.

## 5.2 Genesys Team 2

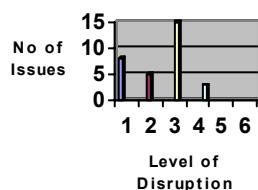
As indicated in figure 4, this team worked consistently well over the entire academic year. Table 5 shows that five of the six members of this team had an NT preference, a typical profile for engineers. The team was very innovative and enjoyed solving new problems and learning new skills. They also showed remarkable patience and resolve when faced with complicated problems. They showed good problem solving abilities throughout the whole project and had a tendency to look at the bigger picture, rather than the small details of each individual part of the system.

**Table 5: MBTI types Genesys Team 2**

ID	Type	E-I	S-N	T-F	J-P
2A	ENTJ	E 11	N 11	T 44	J 67
2B	ENTJ	E 44	N 33	T 11	J 56
2C	ENTJ	E 44	N 1	T 33	J 44
2D	ENTJ	E 34	N 24	T 33	J 22
2E	INTJ	I 44	N 48	T 56	J 33
2F	INFJ	I 54	N 48	F 38	J 37

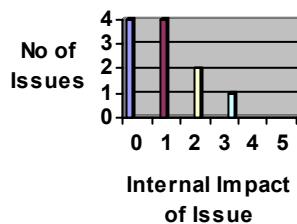
Each member of the team also had a preference for judging over perceiving. This proved vital as there

is the danger that clear intuitive types can lack persistence unless balance is attained through the development of a judging process. Five of the six members also had a preference for thinking over feeling. These people placed a higher value on logic than on sentiment and were on the whole impersonal and businesslike in their relations with each other. This businesslike efficient approach to work was not seen as lacking in sociability, but was viewed as logical sequence of stating the subject, making the necessary points, coming to a conclusion and avoiding repetition.



**Figure 4: Levels of disruption for all issues  
Genesys Team 2**

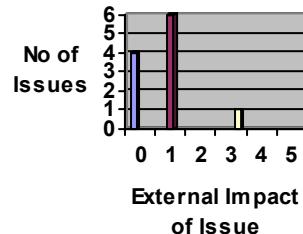
This team was essentially dominated by four ENTJ's, 2A, 2B, 2C and 2D. These characters were primarily interested in possibilities beyond the present, obvious or known. They were also experts at finding solutions to problems; their interest was in the broad picture, however, not in detailed procedures or facts. They were very quick on the uptake throughout the project. This was a good thing as it showed that this team was working well as a unit, and that they were not reliant on one or two individuals. The other team members 2E and 2F proved themselves to be very diligent when given a task; although they weren't prominent members of the team they did their best whilst working on their own part of the project.



**Figure 5: Internal impact of disruptions  
Genesys Team 2**

Figures 5 and 6 show that disruptions and/or lack of debate were not impediments to the efficient progress of Genesys Team 2. The main problems for

this team were contractual issues that arose as the project reached its later stages. Lack of debate in this area led to the client refusing to commit himself to the contract. As they had not signed anything, changes could be made and there was nothing for the team to fall back on.



**Figure 6: External impact of disruptions  
Genesys Team 2**

Intuition was dominant in this team and they always looked at the whole picture and how things would slot together, therefore it was unsurprising that they overlooked a minor detail like the contract, even though it was vital that they got the client to sign it. Finally the management was forced to get involved and informed the client that he had to sign the contract. Being more in tune with the concrete situation at the current time may well have helped them avoid this contractual problem.

### 5.3 Genesys Team 4

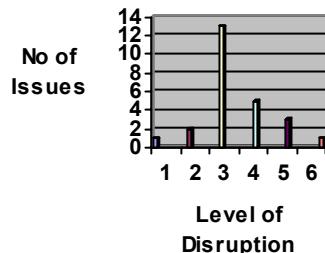
On the whole Genesys Team 4 worked well, as shown in figure 7, but sometimes there was almost too much emphasis on not offending people.

**Table 6: MBTI types Genesys Team 4**

ID	Type	E-I	S-N	T-F	J-P
4A	ISFJ	I 34	S 44	F 24	J 22
4B	ENFJ	E 22	N 78	F 11	J 33
4C	INTJ	I 67	N 11	T 22	J 33
4D	INFP	I 44	N 22	F 28	P 36
4E	INTJ	I 33	N 22	T 44	J 44
4F	ENTJ	E 88	N 67	T 74	J 56

Table 6 shows that this team had a majority of feeling types. They had a natural tendency to consider other people's feelings, reasonable and unreasonable and include their own feelings among the facts to be considered when deciding which solution was the best. The prominent members of the group ensured that each final decision had a sound basis because they took into account facts, possibilities and human values. They

also had a majority of intuitives who were willing to accept ideas if they sounded reasonable and would help develop possibilities.



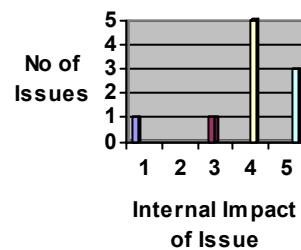
**Figure 7: Levels of disruption for all issues  
Genesys Team 4**

4B and to a lesser extent 4A were the driving forces behind this team. Both of these members complemented each other and had an excellent working relationship. 4B is an ENFJ and 4A is an ISFJ. 4B worked hard to make the other team members feel at ease under all circumstances. They were able to adopt individuals to the objective situation. 4B acted as the unofficial manager of the team and aimed to form and maintain harmonious relationships with other members of the team. Myers-Briggs state that on the whole ENFJs are affable people who fit in well with group-work and have a lot of creativity that can be channeled into new ideas.

4A as an ISFJ was loyal, considerate and interested in the common welfare of other team members. 4A carried responsibility well and was very hard working. The interaction of introversion, sensing and judging gave 4A extreme stability. 4A was balanced by the development of feeling, this judgment helped them to deal with the outside world; it balanced the introverted perception, which by itself is not interested in the outside world. 4A was an excellent foil for 4B in the sense that they were mutually useful as an opposite on the perceiving scale (S-N); 4A favored S, whereas 4B favored N. Both had very clear preferences on their perceiving scale, but both were grateful for the other when discussing project details. Sensing types need intuitive types to bring up new possibilities, to supply ingenuity on problems, to read the signs of coming change and to have enthusiasm. Intuitive types need sensing types to bring up pertinent facts, to apply experience to problems, to face difficulties with realism and to keep track of essential details.

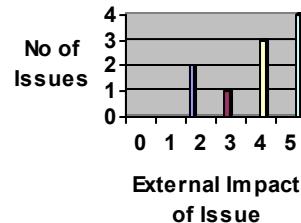
When there was a disruption or no debate the result was often detrimental for this team as shown by figures 8 and 9. Genesys team 4 had several client-

related problems, especially concerning requirements. There was a lot of debate about the length of reports, which carried on into the latter stages of the project. Having meetings and listening to ideas from the client was another source of turmoil. Some members, particularly 4F, accused the client of lying and expressed doubts about his morality and honesty. 4F was successful in creating an atmosphere of mistrust and paranoia with regards to the client by questioning his sanity and integrity. This caused other members to question the clients' integrity. Some members, particularly 4A, felt that the client was making statements based on ignorance but 4F argued that the client was deliberately lying.



**Figure 8: Internal impact of issues  
Genesys Team 4**

There was also a lot of disruptive debate related to project reports. This project was using eXtreme programming (XP) and a lot of this debate was caused by confusion about the nature and role of documentation in an XP project. The XP problems could be put down to a combination of lack of experience from the majority of team members coupled with some serious personality clashes.



**Figure 9: External impact of issues  
Genesys Team 4**

Other disruptions occurred as a result of communication problems and personality clashes between different team members. The net result of all of this was that work plans were missed out of initial monthly reports, resulting in negative managerial feedback, and minutes from previous meetings were

not typed up, creating bottlenecks.

Apathy of team members was exacerbated by a clash between 4F and 4C. There was a lack of enthusiasm from certain team members, particularly 4C; this caused an angry reaction from 4F as a result of this, efforts to involve 4C were largely futile. 4D and 4C tried to push work onto others, and they had to be almost forced to participate in meetings. 4F by shouting and intimidation eventually forced 4C to cut his/her self off from the project. 4B tried to encourage involvement but the situation had gone too far. 4B was forced to remind the team that team working was important and Genesys reflected that. 4B said that 4C's apathy was worrying.

4F was a key figure in many of the disruptions. 4F is an ENTJ with very clear preferences for functions and attitudes. Along with the client, 4C bore the brunt of 4F's onslaught. 4Cs type is INTJ with very clear preferences. 4C complained that a lot of the project was boring, therefore their intuition was being restricted and not given full play. As 4C was also a natural introvert, it was easy to retreat back into a metaphorical shell when faced with problems especially with 4F. The clear preference for thinking caused problems for 4C and prevented him/her from expressing concerns about personal problems. A preference for feeling would have helped 4C to discuss matters and be more open about these personal issues. The judging preference allowed 4C to make a quick decision to keep contact with the rest of the team to a minimum.

The main factor here was the personality type of the people involved with this team. Serious disruption was averted by good man management skills; this was impressive when one considers the diversity of this team and the potentially explosive clashes that could have occurred.

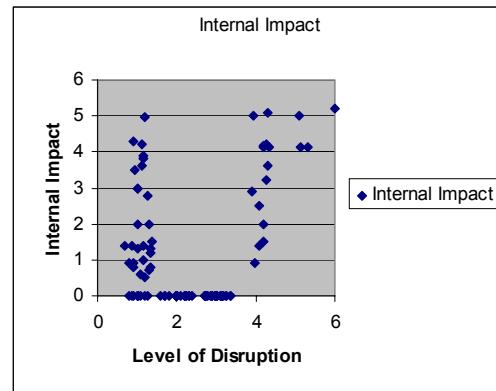
## 6. Aggregation of Results

When discussing the affect of personality types it is important to list both positive and negative aspects, it is clear that some team members contributed more than others in terms of ideas, others contributed more in terms of speaking in public for the team, others contributed more by being a foil for ideas or for working hard behind the scenes, for being a leader or even a peacemaker.

It was also clear that some team members caused more disruption than others; whether it was through anger, apathy or incompatibility with another team member and/or manager/client.

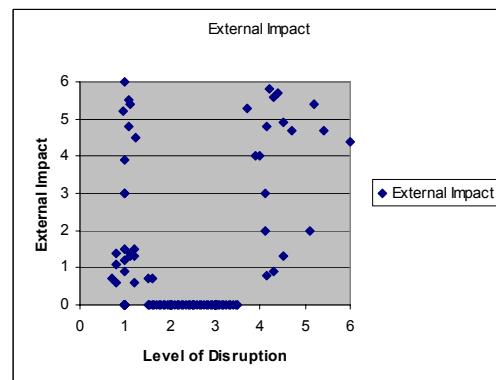
Figures 10 and 11 present the overall results from all five teams for the relationship between level of

disruption and impact. In these figures, multiple data points occurring at the same integer coordinates have been individually perturbed by small amounts, to ensure that they all appear separately.



**Figure 10: Internal impact versus level of disruption, all teams**

The figures illustrate clearly that the notion of a simple linear correlation between the level of disruption of an issue and its impact is completely inadequate. While issues that do cause a high level of disruption (i.e. 5 or 6) do have a significant impact, so too do those with the lowest levels of disruption, and indeed the latter issues often caused more damage to the work done by the teams than those that had produced a high level of disruption.



**Figure 11: External impact versus level of disruption, all teams**

## 7. Discussion

This research supports the idea that the personality profile of a team can be an important factor in determining how well they will work together and how they will approach common problems. With that said personality profiling may not be the whole story, there are other factors that one might need to consider that

are outside the scope of this research, such as ethnicity, gender, the experience of the developers and how people whose first language is not English adapt to an SE team using English in meetings and during dialogue with one another. There are also other factors unrelated to the members of a team that could play a key role in the outcome of a project. Such factors include the client, work-place, methodology and manager. A project that analyzed one or more of these additional factors could find alternative explanations for some of the events observed. This would not invalidate the findings of this research but it would affirm the premise that there is more than one explanation for certain types of behavior.

The results show that different teams encountered different kinds of difficulties, ranging from technical, to client to socio-political. One pattern that emerged was that some homogeneous teams (particularly those dominated by INTs) run a real danger of falling into the no debate trap. For instance would the Maxi team have been worse without B1 who acted as the main spokesman? Or would Genesys team 2 have worked less effectively if more of its members had been INT as opposed to ENT? Based on the observed evidence it would seem that in both cases a more uniform set of personalities would have increased the probability of the team falling into the trap of no debate.

Previous work has raised some interesting questions for those interested in the nature of the personality make up of a team and the question of homogeneity versus heterogeneity in psychological type. The majority view is that a mix of personality types is required, (Teague [6], Capretz [7], Kaiser and Bostrom [4]), but by contrast Rutherford [8] suggests that a heterogeneous science/engineering mix is better.

The fact that the highest performing team observed by the authors had a heterogeneous science/engineering profile adds support to Rutherford's hypothesis. Overall, though, our results support the widely accepted view that it takes a variety of skills and personalities to solve the myriad of problems related to SE. In other words research has tended to support the idea that better software will result from the combined efforts of a variety of mental processes, outlooks and values. The results described here support this view.

## 8. Conclusions

This research has demonstrated that the original hypothesis, that a team dogged by a large amount of disruption would experience more serious problems over the course of a project, was only partly true and not the whole story. A very dangerous situation can

arise when individuals are reluctant to express opinions about something of concern because no one else has mentioned it or because they lack the assertiveness to put the point forward.

Clearly, it is to the advantage of the entire team for each team member to develop interpersonal communication skills. Team members, to create an effective team, need to get acquainted with each other. They need to share their feelings about the project, as well as their levels of expertise. Communication problems can arise as a result of different styles of communication, which are primarily a consequence of ones personality, although in ethnically mixed teams there could also be cross-cultural and language issues to consider.

Such negative outcomes for observed teams without sufficient debate included limiting discussion to only a few alternatives, initial solutions were never reconsidered, alternatives were either not proposed or they were ruled out by the majority of the team resulting in lack of debate on future issues, this lack of debate led to a false confidence in some instances, or to a refusal to make sensible contingency plans.

As far as the research method is concerned, the fact that the lack of discussion proved to be the most damaging problem ensured that accusations of theory loaded observations could be refuted, as the authors expected serious disruption to cause the most severe problems, whereas the work has actually showed that lack of debate is another more serious problem for SE teams that was discovered during this project.

With this in mind the obvious next step is to carry out ethnographic observations on more teams and to couple these with quantitative measurements of actual product quality. This will help to give more validity and reliability to existing studies. It will facilitate the creation of deeper qualitative descriptions of the interactions of different personality types and how they fulfill their role in an SE team.

## 9. Acknowledgements

The authors would like to thank the following colleagues for their help and assistance throughout the project: Chris Thomson, Marian Gheorghe, Mike Holcombe and Stan Price. They both allowed us to observe the teams in manager meetings, and aided us in encouraging the students participate in this study, and to take the online MBTI test which was an essential prerequisite for this work. We are grateful to them for their past and continued support and interest.

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acknowledge them individually, we are grateful to them for their willingness to participate.

## 10. References

- [1] B. Curtis, "Techies as non-technological factors in software engineering," *Proceedings of the 13th International Conference on Software Engineering (ICSE 1991)*, pp. 147-148, 1991.
- [2] R. M. Belbin, *Management Teams: Why they succeed or fail*. Oxford: Butterworth-Heinemann, 1981.
- [3] K. T. Stevens and S. M. Henry, "Using Belbin's leadership role to improve team effectiveness: an empirical investigation," *Journal of Systems and Software*, vol. **44**, pp. 241-250, 1999.
- [4] R. P. Bostrom and K. M. Kaiser, "Personality Differences within Systems Project Teams: Implications for Designing Solving Centers," *Proceedings of the 18th Annual Computer Personnel Research Conference*, pp. 248-285, 1981.
- [5] J. J. Elam and W. D. Walz, "A study of conflict in group design activities: implications for computer supported cooperative environments," *Proceedings of the 21st Annual Hawaii International Conference on Decision Support and Knowledge Based Systems Track*, pp. 247-254, 1988.
- [6] J. Teague, "Personality Type, Career Preference and Implications for Computer Science Recruitment and Teaching," *The Proceedings of the third Australasian Conference on Computer Science Education (ACSE 98)*, pp. 155-163, 1998.
- [7] L. Fernando-Capretz, "Personality Types in Software Engineering," *International Journal of Human-Computer Studies*, vol. **58**, pp. 207-214, 2003.
- [8] R. H. Rutherford, "Using Personality Inventories to Help Form Teams for Software Engineering Projects," *ACM SIGCSE Bulletin, Proceedings of the 6th Annual Conference on Innovation and Technology in Computer Science Education*, vol. **33**, pp. 73-67, 2001.
- [9] A. J. Cowling and J. S. Karn, "An initial observational study of the effects of personality type on software engineering teams," *Proceedings of the 8th International Conference on Empirical Assessment in Software Engineering (EASE 2004)*, pp. 155-165, 2004.
- [10] A. J. Cowling and J. S. Karn, "An initial study of the effect of personality on group projects in software engineering," *Department of Computer Science Research Report CS-04-01, University of Sheffield*, 2004.
- [11] C. G. Jung, *Psychological Types*, vol. **6**: Harcourt Press, 1923.
- [12] I. B. Myers and P. B. Myers, *Gifts Differing: Understanding Personality Type*. California: Davis Black Publishing, 1987.
- [13] HumanMetrics, "<http://www.humanmetrics.com/cgi-win/JTypes2.asp>"
- [14] P. Costa and R. McCrae, "Four ways, five factors are basic," *Personality and Individual Differences*, vol. **13**, pp. 653-665, 1992.
- [15] A. Furnham, "The big five versus the big four: the relationship between the Myers-Briggs Type Indicator (MBTI) and NEO-PI five factor model of personality," *Personality and Individual Differences*, vol. **21**, pp. 303-307, 1996.
- [16] A. J. Cowling and J. S. Karn, "A Study into the Effect of Disruptions on the Performance of Software Engineering Teams," *Department of Computer Science Research Report CS-04-17, University of Sheffield*, 2004.