

A Field Research on the Practices of High Performance Software Engineering Teams

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Abstract: This paper presents the results of a field research aiming at identifying the practices adopted by High Productivity Software Engineering Teams. This field research was developed through interviews with project managers from several companies with the following objectives: to evaluate the knowledge of the professionals in relation to the characteristics of the high performance teams found in the literature; understand and identify which practices companies use to develop each high performance characteristic; identify the training approaches that are used to improve the professionals in each practice.

1 INTRODUCTION

The software development market operates in a global environment, with rapid changes, and needs to respond to these new opportunities and new markets with agility (Sommerville, 2010). Achieving agility, competitiveness and results without a qualified software development team and high performance is a difficult task and can bring results that are not very competitive.

A study done in 2015 by Standish Group (Hastie and Wojewoda, 2015) with a sample of 10,000 projects around the world produced a report called "Chaos Manifesto 2016", which revealed that the Information Technology (IT) industry faces several challenges; although 29% of the IT projects have been successful, being delivered before the deadline and within the estimated cost; 52% of the IT projects were delivered after the deadline and more expensive than the original plan; and 19% of the IT projects were total failures, being cancelled before the delivered time, or were delivered but never used. Faraj and Sambamurthy (2006) say that improving the productivity and quality of projects are important. Initial approaches were focused on discovering better methodologies and tools, but there is an increasing perception that the projects also face several challenges related to communication, coordination, learning, negotiation, diversity and on how to form high performance teams for software development projects.

This context indicates that the qualified education and training of professionals is more necessary in the society in which we live. Whether in short courses, or at the undergraduate or graduate level, training good professionals it is part of the commitment a Higher Education Institution (HEI) has in the society (Dannelly and Steidley, 2001). Beckman (Beckman et al., 1997) say that, among other factors, the quality of the professional is directly related to the quality of the education he/she received.

The quality of SE training can contribute meaningfully to improvements in the state of the art of software development and aid in solving some traditional problems and crises related to software industry practices (Gibbs, 1994). Training and capacity-building to prepare a software professional must include not only basic knowledge of the Computer Science field, but also the teaching of concepts, processes and techniques for the definition, development and maintenance of software (Saiedian, 1999; ACM/IEEE, 2008).

As a result, the education process in Software Development has begun to question the methods used in training activities (Beckman et al., 1997). Recent studies observe that these methods involve traditional teaching strategies such as theory presentation, expositive classes and complementary reading. In this scenario, students find in the industry a different scenario than what is taught in academia (Prikladnicki et al., 2009). At the same time, software development projects have required high performance team

training, and professionals with strong technical, behavioural, and business skills which current educational programs are not able to supply (Monsalve et al., 2011). One of the reasons is the fact that such programs concentrate on basic education focused on the traditional approaches for software development, instead of preparing the professional to act as a part of a software development team, which requires multifunctional competencies and a multidisciplinary environment.

Thus, the goal of this paper is to develop a reflection about how the current existing SE training approaches cover the various high performance teams characteristics. We first conducted an ad-hoc literature study about the existing training approaches in SE and then a systematic literature review (SLR) about high performance teams characteristics. At the end, we reflected on how the existing training approaches help in forming high performance software development teams.

This paper is divided into six sections. In Section 2 we present the theoretical foundations. In Section 3, we report on existing training approaches. Section 4 provides a field research on high performance teams practices. Finally, in Section 5 the conclusions and future work are addressed.

2 BACKGROUND

2.1 Software Engineering Training

Software Engineering is concerned with theory application, knowledge and practice for the effective and efficient software development of systems that satisfies users requirements (ACM/IEEE, 2008). SE began to be discussed as a discipline in 1968 (ACM/IEEE, 2004) and currently is part of the curriculum of several courses such as Computer Science, Computer Engineering, Information Systems, Automation Control Engineering and Software Engineering.

Software Engineering is related with all software production aspects, from the initial stage to its maintenance, involving not only technical development processes, but also project management activities and tools, methods and theories that support its production (Sommerville, 2010). Therefore, SE goes beyond programming code creation; it tries to discipline development and brings to software development principles, techniques and knowledge to discuss quality questions, deadlines and economic factors (ACM/IEEE, 2004).

The professionals who conclude their undergraduate course, according to curricular recommendations, are able to, among other aspects, master knowledge and abilities that are part of the SE area; work individually or as part of a team to develop software artefacts with quality; design solutions using appropriate SE approaches that integrate ethical, social, legal and economic questions; know how to apply current theories, models and techniques that provide a baseline for identifying and analyzing problems, software design, development, implementation, verification and documentation; demonstrate understanding and appreciation of the importance of negotiation, efficient work habits, leadership, and good communication with stakeholders; and learn new models, techniques and technologies as soon as them emerge (ACM/IEEE, 2004).

By analyzing the curricular recommendation listed, we have identified that there are several required competencies for a SE professional. The SE curriculum (ACM/IEEE, 2004), (ACM/IEEE, 2008) points to the necessity of education apart from expositive class formats, and one of the way to increase education quality involves innovative strategies and didactics. According to Beckman (Beckman et al., 1997), educational quality is one of the important factors that influence the quality of the professionals. Thus, some of the challenges for improving SE education are: to make SE courses more attractive to students; to focus appropriately on SE education, understanding its dimensions; to present industry practices to the students; provide education to industry professionals; to make education in SE evidence-based; to ensure that SE educators have the necessary experience and knowledge to this assignment; and to increase the research prestige and quality of the educational SE (Sommerville, 2010).

According to Conn (Conn, 2002), the SE professionals are dissatisfied with the lack of training of the university students that enter the work market, which means that the industry must complement their education with training that gives them necessary knowledge in order to make up this deficiency. This training can involve professionals or teams, including high performance teams.

2.2 High Performance Teams

A high performance team is a group that brings together members committed to the mutual growth and personal success. According to Chiavenato (2008), the main high performance teams attributes are: participation, accountability, clarity, interaction,

flexibility, focalization, creativity and quickness. According to Cleland and Ireland, the participation in a team increases the commitment and the fidelity of the people, resulting in delivery of high quality, work (Cleland and Ireland, 2000).

According to Moscovici, a high performance team, besides all the requirements of a team as was explained in the previous section, must have its members must be committed to the personal growth and success of each team member. Such a team will exceed the performance of all the other teams and achieve results above expectations (Moscovici, 2003).

Katzenbach and Smith (1993), present some characteristics of high performance teams: "Deeply personal commitments of each one to the growth and the success of the others is what distinguish high performance teams from the majority of the existing teams. Energized by this extra sense of commitment, the high performance team typically reflects a vigorous amplification of the fundamental teams characteristics: deeper sense of purpose, more ambitious performance targets, a more complete approach, more fullness in mutual accountability, knowledge interchangeably and complementarity."

Boyett and Boyett mention some companies that have achieved great results with high performance teams. The AT&T Credit Corporation has used high performance interfunctional teams in order to improve its efficiency and service to the client (Boyett and Boyett, 1998).

According to Raj (Raj et al., 2006), it is noticed that there is a major difficulty for an organization in disseminating high performance team practices, such as work reorganization, professional involvement in decision making processes and improvement in workers's skills, despite the evidence that organizations invest in these practices to achieve greater productivity and efficiency. Companies with significant performance standards, according to Katzenbach and Smith, stimulate and support high-performing teams, helping them to establish their own goals (Katzenbach and Smith, 1993).

3 TRAINING APPROACHES IN SE

Training in SE should prepare the students in both theory and effective participation in a collaborative and interdisciplinary environment. In this regard, it is important consider the variation in training techniques.

Traditional approaches in SE training are considered to be (Anastasiou, 2004):

1. Dialogued expositive classes: This is a content exposition, with active participation by the students, whose previous knowledge must be considered and can be taken as a foundation.
2. Text Study: This is an exploration of an author's idea from the critical study of a text and/or information research and the author's ideas exploration.
3. Directed Study: This is study under guidance and direction by the professor, aiming to solve specific difficulties.
4. Use of a Discussion List: This is an opportunity for group of people be able to debate, at a distance, a theme in which they are experts or have done a previous study.
5. Verbalization and Observation Groups (VG/OG): This is an analysis of theme/problem under a professor's coordination that divides the students in two groups: one for verbalization (VG) and the other for observation (OG).
6. Seminar: This is a space where a group discusses or debate themes or problems.
7. Case Study: This is the detailed and objective analysis of a real situation that needs to be investigated and that is challenge for the people that are involved.
8. Workshop: This is the gathering of a small number of people with common interests, which aims to study and work for the knowledge and deepening of a theme, under expert orientation.

These alternative approaches can help students to learn more effectively. Alternative approaches are considered to be (Prikladnicki et al., 2009) (Gresse and Shull, 2009), (Monsalve et al., 2011), (Halma, 2014):

1. Group Activities, distance education and practice activities: By using this approach, interaction with the students is emphasized through icebreakers that explore specific subjects. The characteristics are: diversification in the techniques for group activities; practical classes in laboratories; the planning of the student work; and part-time classes: 20% of the discipline is done through distance education.
2. Capstone projects and practices activities: a Capstone project is an approach where a student group plans and executes a software project from the beginning to the end during one whole semester.

3. Playgroup and games: For this strategy, related content is first presented to the class. In the end, in order to consolidate comprehension, a playgroup is performed using LEGO®. The game makes it possible to design, from the defined requirements, a product to be built that is similar to the software development.
4. Games and educational simulators: Because of the need for training students in the SE process, one of the alternatives is the use of games to fill the gap between theoretical and practical aspects. From the reports found in the literature (Monsalve et al., 2011), it was noticed that the majority of the proposals developed are associated with simulator games.

The approaches that are more focused on the students and that promote their further active participation on the classes, for example with games and simulators (Monsalve et al., 2011), (Halma, 2009), have the potential to increase the students interest, motivate them and improve learning at level of concept application.

4 FIELD RESEARCH ON HPT PRACTICES

This field research was developed through interviews with project managers from different companies, with the following objectives:

- Evaluate the knowledge regarding the performance of high performance teams in the literature;
- Understand and activate skills for companies to become each high performance characteristic;
- Identify how training approaches are used to improve the professionals in each practice.

4.1 Field Research Protocol

An exploratory, qualitative, non-experimental, survey-type field survey was developed for a semi-structured interview with open and closed questions. The application of the questionnaire was made through personal interviews. The following procedures were developed:

- a) Meetings to raise questions and structuring the interview guide;
- b) Review of interview guide;
- c) Authorization of participating companies;

- d) Validation of face and content;
- e) Application of interviews.

The research respondents were project managers, project leaders, and project coordinators. The resources used were technological resources (computer, text and spreadsheet software) and materials resources (a meeting room in the organization's own headquarters for half an hour, a recorder to record interviews, paper and pen). Data collection was done through semi-structured interviews with open and closed questions. The questionnaire will be applied with personal interviews.

In the analysis of data, a critical analysis of these results was made through the development of a comparison of the results obtained with the theories and related studies (Dutra et al, 2015). The interviews were recorded and a qualitative analysis of the collected data was carried out through a mapping of the respondents' responses.

4.2 Field Research Execution

After we defined the research protocol, the field research was executed.

In the face-to-face interviews, tape recorders were used because according to Schraiber (1995), the use of tape recorders in interviews is indicated to amplifying the power of recording and capturing extremely important communication elements, pauses for reflection, doubts or intonation of the voice, enhancing the understanding of the narrative. Authors such as Patton (1990) agree with this statement because the recorder preserves the original content and increases the accuracy of the data collected.

After all the interviews were carried out, each of them was transcribed. As soon as the transcription of the information was finalized, the analysis of the data was started. According to Bardin (2004), the most used form of treatment is Content Analysis, that according to Oliveira (Oliveira et. al, 2003), consists in the detailed reading of all the transcribed material, in the identification of words and sets of words that have meaning for the research, as well as in the classification in categories or themes that have similarity to the syntactic or semantic criterion. Still, according to Olabuenaga and Ispizúa (1989), content analysis is a technique for reading and interpreting the content of all kinds of documents, which, if it is properly analyzed, opens the doors to the knowledge of aspects and phenomena of social life otherwise inaccessible.

In this field research, the Thematic Analysis technique was used, which, according to Bardin (2004), is inserted in the set of Content Analysis techniques, whose objective is to highlight the items of meaning from the description of the "corpus" constructed based on the coding units or cut-out categories of the content of interviews and documents, which are guided by the problem and objectives of this study (Bardin, 2004).

Bardin (2004), explains that this dialogue - understood in the light of varied contextual categories and information - makes interpreting as an intrinsic element of the research process. Based on these procedures, the different phases of analysis were covered: (1) transcription and pre-analysis; (2) floating reading and exploration of the material with the establishment of categories; (3) data processing from logical inference and interpretation; and (4) confrontation and discussion of the results obtained with the theories and related studies of the systematic review of developed literature.

4.3 Field Research Results

Based on the research developed, we analyzed the demographic data of the professionals interviewed, according to Table 1.

Table 1: Demographics of participants.

Age	Respondents
21-30	1
31-40	5
41-50	14
Sex	
Female	7
Male	13
Experience in Project Management	
1-5 years	4
6-10 years	3
11-15 years	12
16+ years	1

Most of the interviewees are male, between forty-one and fifty years old, and work between eleven and fifteen years in the activity of managing software projects.

In turn, Table 2 gives us information about the time and projects developed with a high performance team. It shows if the interviewee worked on projects in which a high performance team participated, how much time worked with this team and how many projects were developed.

Table 2: Time and projects developed in HPT.

Worked with HPT	Number of Votes
Yes	19
No	1'
Time that worked with HPT	
0-1 year	13
2-3 years	6
3+ years	0
Projects with HPT	
1-5 projects	16
6-10 projects	1
10+ projects	2

4.3.1 Data Analysis

To determine which characteristics of a high performance team are most relevant to the research, we used 75% heuristics, that is, three quarters of respondents should agree that the attribute is a high performance characteristic, as shown in the following table. This number is higher than that found in similar studies in the literature, which suggest that when an opinion is shared by at least 50% of the respondents, it should be treated as a relevant impact opinion for the study in question (Ali-Babar and Niazi, 2008). Table 3 presents the characteristics of the high performance teams, the number of votes for each characteristic and their totals.

Table 3: Ten most relevant characteristics.

#	Attribute	HPT's characteristic (Yes)	HPT's characteristic (No)	%
1	Know how to work in a team	19	1	95%
2	Solid knowledge	18	2	90%
3	Effective communication	17	3	85%
4	Efficient coordination	17	3	85%
5	Diversity of skills	16	4	80%
6	Autonomy at work	16	4	80%
7	Organizational commitment	16	4	80%
8	Unforeseen technical challenges	16	4	80%
9	Self-manageable	16	4	80%
10	Confidence in their own abilities	15	5	75%

The most selected characteristic in the field survey was "know how to work in a team", with 19 votes, followed by "have a solid knowledge", with 18 votes, and 17 votes were to "have an efficient coordination" and "have effective communication.

4.3.2 Categorization

Coding is the process by which raw data is systematically transformed into categories, allowing subsequent discussion of the relevant characteristics of the content (Franco, 1986).

As Olabuenaga and Ispizúa (1989) said, the process of categorization must be understood, in its essence, as a process of data reduction. The categories represent the result of an effort to synthesize a communication, highlighting in this process its most important aspects.

First, the data were prepared and, after the transcriptions, a careful reading was made, in order to

seek the researcher's familiarity with the data before starting the coding of the categories. In this coding process, open coding and selective coding were used. Open coding involves the breaking, analysis, comparison, conceptualization, and categorization of data. According to Bandeira-de-Mello and Cunha

Table 4: Practices for the characteristic: know how to work in a team.

Know how to work in a team	Categories	Practices Found
Know how to work in a team	Methodology	<ol style="list-style-type: none"> 1. Develop team-wide project scope discussions through pre-planning and pre-games 2. Develop agile teams, perform Scrum ceremonies with the project team (planning, daily, retrospectives), sharing experiences, listening, trying to help 3. Define a working methodology
	Team Building	<ol style="list-style-type: none"> 1. Encourage and stimulate teamwork 2. Develop HR integrations 3. Develop self-protection of the team (the team protects itself) 4. Use a team mailing list to exchange messages 5. Make small celebrations in the deliveries of the projects 6. Work towards a common goal by trying to help your peers 7. Focus much more on the whole than an individual focus
	Allocation	<ol style="list-style-type: none"> 1. Make the allocation of the team according to the project's characteristic and skills of the members 2. Have people working physically close 3. Make new allocations within the same project, changing the context in the middle of the project, forcing a synergy between the teams and focusing on the need to work together

(2006), in the initial stages of open coding, the researcher explores the data by examining in detail what seems relevant to him due to the intensive reading of the texts. Table 4 exemplifies the initial codifications of this research, and in this first stage 170 practices were found.

With the defined categories, it moves to an intermediate level of abstraction, seeking the relation between them to form the basis for its theoretical construction. This process is called "axial coding". In this stage, the number of practices was 135.

In the table 5, we have: (1) the main characteristic, (2) the total of categories linked to this characteristic, and (3) the total of practices extracted from the interviews for the formation of high performance teams in Engineering Software.

Selective coding is the final step in data analysis and coding, and its purpose is to integrate and refine the constructed categories. Selective coding is being developed throughout the entire data collection and analysis process, since integration is a continuous process.

The final categories found in this field survey, and this final step was completed with 106 practices.

The final categorization of the characteristics of HPT found in this survey were:

1. Know how to work in a team: Methodology, Team Building and Allocation
2. Solid knowledge: Knowledge and Formation
3. Efficient coordination: Team Management, Methodology, Roles and responsibilities and Communication
4. Effective communication: Methodology, Communication, Allocation, Feedback, Management and Tools
5. Organizational commitment: Commitment, Strategy, Team Building and Feedbacks
6. Diversity of skills: Knowledge, Feedback, Team formation, Rotation and Exchange of experiences
7. Self-manageable: Energy, Autonomy, Communication and Methodology
8. Autonomy at work: Autonomy, Leadership and Methodology
9. Unforeseen technical challenges: Knowledge, Skills and Contingency Analysis
10. Confidence in their own abilities: Roles and responsibilities, Knowledge and Recognition

From the identification of the categories linked to the characteristics of the high performance teams, the data collected were extracted from the interviews, categorized, and from the identification of the categories, the practices were listed. This field survey, for ten high performance characteristics, totaled 106 high performance team practices in 37 categories, as shown in Table 5.

Table 5: Number of characteristics x categories x practices.

Characteristics	Categories	Practices
1. Know how to work in a team	3	13
2. Solid knowledge	2	7
3. Efficient coordination	4	14
4. Effective communication	6	16
5. Organizational commitment	4	11
6. Diversity of skills	5	10
7. Self-manageable	4	11
8. Autonomy at work	3	5
9. Unforeseen technical challenges	3	11
10. Confidence in their own abilities	3	8
Total	37	106

5 CONCLUSIONS

As a conclusion of this field research, we can say that of the three objectives defined for the research, only two were successfully completed.

Objective 1, to evaluate the knowledge of the professionals regarding the characteristics of the high performance teams found in the literature, was successfully achieved, since the characteristics of the high performance teams found in the Systematic Review of Literature (Dutra et al, 2015), were cited by the interviewees as characteristics of high performance teams.

Objective 2, to understand and identify the practices companies use to develop each high performance characteristic, has also been

successfully completed. As shown in Table 5, 106 practices of high performance teams were identified in 37 different categories.

The ultimate goal of this field research was to identify the training approaches that are used to enhance people in each identified practice, but this goal was not successfully completed. That is because, it was not possible to find such approaches in the data extracted from the interviews. In most cases, the interviewees focused on mentioning what training was made for a particular practice rather than the training approach that was developed. Considering this difficulty in extracting the approaches, a new study was developed with the objective of searching in the literature the training approaches, the characteristics of the high performance teams most cited in field research.

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