Towards High Performance Software Teamwork

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ABSTRACT

Context: Research indicates that software quality, to a large extent, depends on cooperation within software teams [1]. Since software development is a creative process that involves human interaction in the context of a team, it is important to understand the teamwork factors that influence performance.

Objective: We present a study design in which we aim to examine the factors within software development teams that have significant influence on the performance of the team. We propose to consider factors such as communication, coordination of expertise, cohesion, trust, cooperation, and value diversity. The study investigates whether and to which extent these factors correlate with a performance of the team. In order to capture a variety of relevant teamwork factors, we created a new model extending the work of Hoegl and Gemuenden [2] and Liang et al. [3].

Method: The study is based on quantitative research by means of an online questionnaire. We invited more than 20 software development teams in the Netherlands to participate in our team performance assessment, evaluating the teamwork and performance of the team. Based on an average team size of five people, one would therefore expect at least 100 participants in total. Also, product stakeholders will be asked to give their independent assessments of the performance of the team.

Expected result: By analyzing the correlation between teamwork factors and team performance, we expect to gain a deeper understanding of how teamwork factors influence team performance. We also expect to validate the implemented extensions of teamwork model with respect to earlier work.

Categories and Subject Descriptors

D.2.8. [**Software Engineering**]: Metrics - *performance measures*

General Terms

Measurement, human factors

Keywords

Teamwork factors, team performance, software development, software teams

1. INTRODUCTION

Software quality, to a large extent, has shown to be dependent on good teamwork [2][3][4]. Hoegl and Gemuenden [2] studied the influence of six teamwork quality (TWQ) factors – *viz.* communication, coordination, balance of member contribution, mutual support, effort, and cohesion – on the success of innovative projects. The results were promising; the TWQ factors were significantly correlated with performance ratings. However, TWQ only explained 41% of the variance of team member ratings, 11% of team leader ratings, and 7% of the manager ratings of team performance. Based on general sociological research, we propose to extend the model with further factors. Trust, for example, is found to be a key predictor for team performance [5] and an important support mechanism for teamwork [6][7].

Building on the TWQ model [2], we propose a model that contributes to existing literature to answer the question: How is teamwork related to the performance of software development projects? How strong is the relationship between the different teamwork factors and performance?

The expected contributions of this work are as follows: (1) we perform an independent verification of some of the factors of the TWQ model of Hoegl and Gemuenden; (2) we extend the model with factors such as trust for which we have indications that they are important for software projects; (3) we validate our more encompassing model by measuring the relationship between the various aspects of teamwork and performance.

Results of this work will have the following practical implications. If we can identify what teamwork factors contribute to higher performance, software managers will be able to use this knowledge to build and manage teams more constructively. Self-organizing teams (as prevalent in Agile software development) will be able to use this knowledge to enhance their performance [8].

The remainder of this research proposal is structured as follows: In Section 2, we briefly discuss and critically review some related work about teamwork and software development. Given several shortcomings in earlier work, we propose an extended model to capture teamwork factors in Section 3. In Section 4, we outline the proposed research methodology for validating the model. Section 5 summarizes and describes future work.

2. RELATED WORK

2.1 Teams, Teamwork and Performance

Following Hoegl & Gemuenden [2], *teams* can be defined in terms of (1) their context, a social system that is embedded in an organization, (2) identity, members of the team are perceived to be a member of the team by themselves and by the others, and (3) teamwork, members work together on a common task. To accomplish their common goals, team members must work together. Each member of a team has a specific role and specific *individual taskwork*. This is the individual activity of a team member that does not require interdependent interactions with other member of the team. *Teamwork*, on the other hand, is the activity of multiple interdependent individuals [9]. The multilevel process that arises when team members are involved in managing their individual task- and teamwork and the teamwork processes, is defined as *team performance* [10]. Team performance can be assessed in terms of effectiveness and efficiency. *Effectiveness* is the degree to which a team meets the expectations of the quality of the outcome [11].

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Efficiency refers to the degree to which the team met time and budget objectives [2].

2.2 Teamwork Factors

Communication. The fundamental component of teamwork is communication. It provides a mean to exchange information, share ideas among team members, coordinate efforts and provide feedback [13]. Not only the exchange of information is important, even more important is that the information is delivered to the right person and interpreted in the way the sender intended to [13][14][15]. Since communication provides a basis for other factors that determine team performance such as coordination [16], cohesion [17], and trust [18], it is an important factor. Communication can thus be seen as a primary tool that is needed to create a high-performing team.

Coordination of Expertise. Hoegl and Gemuenden [2] argue that coordination is an important aspect of teamwork. It refers to the development and agreement of a team of a common task-related goal structure, with well-defined subgoals for each member, without any gaps or overlaps. Since software development is knowledge work, expertise is an elementary resource, which is not considered in the study of Hoegl and Gemuenden [2]. Coordination of expertise refers to the "management of knowledge and skill dependencies" [12]. This includes knowing where expertise is situated within a team, recognizing the need for expertise, and bringing expertise to good use.

Cohesion. Team cohesion refers to the interpersonal attraction of team members, their commitment to the team task, and group-pride spirit [19]. Cohesion is an important antecedent for team performance [20]. Without a sense of belonging and a desire to stay on the team and keep it going, high quality teamwork seems improbable [2]. Especially when the team task required high coordination and communication, hence, in software development, cohesion was found to be important [21]. However, Mullen and Copper [19], in their meta-analysis, revealed disagreements about the relationship between group cohesion and performance in literature. They conclude that this relationship is small but significant. Nevertheless, factor analyses of Hoegl and Gemuenden [2] showed the highest factor loading for cohesion, implicating that of all six TWQ factors, cohesion correlates the strongest to performance.

Trust. Friedlander [5] found that trust is a key predictor for team performance. There are many different definitions of trust. Following Mayer, Davis and Schoorman [22], we define trust as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control the other party". Trust is an important supporting mechanism of teamwork since it has influence on many team processes such as the willingness to share information, give substantial feedback and manage time correctly [6]. Furthermore, trust fosters the way team members interpret others' behaviors such as performance monitoring [7].

Cooperation. Cooperation is an essential element of teamwork in software development teams. The idea of teamwork is based on the idea of cooperation of the team members rather than the competition between them [2]. Team members working on a shared goal should try to support instead of trying to outdo each other. They should show respect, give help and support when needed, and stimulate ideas of other team members and develop them further. If, on the other hand, team members demonstrate competitive behaviors, this can lead to distrust and frustration within the team [23]. Cooperation, therefore, is an important element of teamwork and needed to be able to reach team objectives.

Value Diversity. Value diversity arises when team members have a different perspective on the team's task, goal, or mission. Such differences can lead to relationship, task, or process conflict [24][25]. For example, team members who value quality are likely to get into conflict with members who value efficiency. Low value diversity is needed to be efficient, effective and sustain a high moral within the team [25]. Hoegl and Gemuenden [2] argue that especially norms about the effort of team members are important for TWQ. However, effort is only one of the multiple facets team members might have shared expectations about. Value diversity regards the team goal and mission, which is on a higher order than effort. Hence, when team members share the same mission or vision, it is likely that they will prioritize the task of the team and have the same ideas regarding work norms.

Team performance. Team performance is considered to be the assessment of the ability of a software development team to attain the aimed level of costs, time and product quality. Software development projects, therefore, can be described as successful when a product with the desired level of quality is delivered within the pre-determined time and cost limits [26]. It considers three aspects of software development: (1) product quality, (2) efficiency, and (3) effectiveness. Evaluations of team performance, therefore, can vary across team members, team leaders and stakeholders. Hence, it is important to have multiple ratings of team performance, coming both from sources both internal and external to the team [2].

3. THE EXTENDED MODEL

The focus of our study is on the quality of interactions within software development teams. Based on the TWQ model of Hoegl and Gemuenden [2], a new model is developed. Hoegl and Gemuenden [2] built their model upon the fundamental idea that the success of teams depends on the degree to which team members are able to collaborate. The six facets of the TWQ model – communication, coordination, balance of member contributions, mutual support, effort, and cohesion – are intended to comprise measures of team internal interaction that are relevant to performance. There are several arguments to question this selection of factors. First, trust, for example, is excluded while this is a key predictor for team performance [5]. Furthermore, according to Hoegl and Gemuenden's [2] criterion of choosing the TWQ factors, trust should have been included. Second, Hoegl and Gemuenden [2] argue that especially norms about the effort of team members are important for TWQ. However, we argue s that measuring norms about effort is not all-encompassing. Therefore we propose to use a generic measure of value diversity instead. Third, balance of member contributions measures whether contributions to the team are balanced in terms of member's specific knowledge and experience. By using Faraj and Sproull's [12] measure of coordination of expertise, both balance of member contributions and coordination are sufficiently covered.

We therefore arrive at the following factors for our model: communication, coordination of expertise, cohesion, trust, cooperation, and value diversity (see Figure 1).

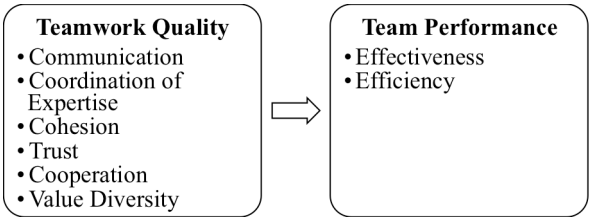

Figure 1. Independent and dependent factors of the extended teamwork model

Based on the purpose of the study, we arrive at the following research questions:

RQ1. Which factors influence performance?
RQ2. How does the extended model perform with respect to the original model of Hoegl and Gemuenden [2] ?

We will perform statistical analysis to verify if the assumption holds that a model that includes trust, value diversity, and coordination of expertise contribute more to explaining project success than the factors of Hoegl and Gemuenden [2] alone.

4. METHOD

Data collection. We propose to have a sample of at least 100 participants to be able to conduct statistical analyses with the margin of error smaller than 10% at a confidence level of 95%. Based on an average team size of five, this would imply at least 20 software development teams are required. Teams should fulfill the following conditions: (1) it has to be a software development team (2) of at least three members (3) that is embedded in an organization (4) and whose members consider themselves to be a team. Diversity in terms of, for example, team size, development method, programming language, type of application, and size of application is a plus.

Participation recruitment will be done through snowball sampling, making use of a network such as a CIO platform. Managers or team leaders can then be approached by email or phone and invited for a personal meeting to give more information about the study. After informing the manager or team leader about the objectives of the study and its procedure, they can contact and inform team members and stakeholders about the study and procedures.

We propose to use an online questionnaire to minimize time and costs and maximize respondent convenience. Clear instructions should be given to the participants about the procedure to try and make the environmental conditions as similar as possible. This includes honesty, a quiet environment, no distortions and filling out the questionnaire in one go. Team managers/leaders can be asked to distribute the link to the questionnaire amongst the team members and relevant stakeholder(s).

Measures. Following the scope of this study, all measures should assess interactions on a team level. It is advised to do a pretest to ensure construct validity and quality of the items. We propose to adopt multiple item constructs from prior research studies and measure all items on a 5-point Likert scale ranging from 1 (= strongly disagree) to 5 (= strongly agree). All measures for the factors of our extended model are summarized in Table 1.

Following Hoegl and Gemuenden [2], *communication* can be measured using the 5-item scale of Liang, Wu, Jian and Klein [3]. Questions included focus on the frequency of the communication, its spontaneity, team member satisfaction of the timeliness of the information they received, its precision and its usefulness. *Coordination of expertise* can be measured with four items for knowing expertise location, three items for recognizing the need of expertise, and four items for bringing expertise to good use [12]. We propose to use the Cohesion Measurement Scale (CMS) of Chin, Salisburry, Pearson and Stollak [28] to measure *cohesion*. This 6-item scale asks participants whether they feel they belong to the group, are happy to be part of the group, see themselves as part of the group, and if they are content to be part of the group. *Trust* can be measured using Jarvenpaa, Knoll and Leidner's [18] 5-item scale. Participants are asked, for example, if they consider their team members to be trustworthy, friendly and reliable. *Cooperation* considers the degree to which, for example, team members support each other and respect and further develop suggestions and contributions of other team members. Hoegl and Gemuenden's [2] 6-item scale of mutual support can be used to measure this factor. Finally, Jehn's [24] well-known measure of *value diversity* can be used to measure the sixth teamwork factor. This 6-item scale measures if team members share the same values, goals and mission. High scores on this scale indicate low value diversity.

Table 1. Proposed measures for the extended teamwork model factors

Communication. There is sufficient frequent, spontaneous, timeliness, precise and useful exchange of information.	Liang, Wu, Jiang and Klein [3]
Coordination of Expertise. Location and need of expertise are known and coordinated.	Faraj and Sproull [12]
Cohesion. Team members are motivated to maintain the team and there is team spirit.	Chin, Salisbury, Pearson and Stollak [27]
Trust. Team members trust each other.	Jarvenpaa, Knoll and Leidner [18]
Cooperation. Team members help and support each other in carrying out their tasks.	Hoegl and Gemuenden [2]
Value Diversity. Team members share the same values and goals.	Jehn [24]
Project Performance. The degree to which the project team completes the project efficiently and effectively.	Jones and Harrison [1]

Following Hoegl and Gemuenden [2], we propose to measure *team performance* using multiple perspectives, asking both team members and project stakeholders to give their independent assessment. Stakeholders are individuals that are not a formal member of the team, but who are directly affected by the performance of a team. These may include project sponsors or managers who are responsible for the production and implementation of the system. Team performance considers the degree to which the project goals are met, the expected amount of work is completed, the level of quality is delivered, the schedule is met, the operations are carried out efficiently and within time limits, and to which extent the budget is adhered to [1]. This 7-item measure of Jones and Harrison [1] is based on Henderson and Lee's scale [4].

Data analysis. To be able to compare the extended model with the original, we propose to use the same analyses as Hoegl and Gemuenden [2]. These include the following: (1) test homogeneity of within-team ratings before calculating the mean team rating by aggregating the data; (2) factor analysis to test if all factors relate to the same construct; (3) factor analysis at the individual factor level to warrant that the team level results are not a consequence of inflated correlations because of the data aggregation; (4) structural equation modeling (SEM) to test the measurement and structural models.

After conducting above-mentioned tests, the explanatory power of the extended model can be compared to that of the original. It can be observed how much explanatory power is lost after removing the factors coordination, balance of member contributions, and effort and how much is gained when coordination of expertise, value diversity and trust are added.

5. CONCLUSIONS & OUTLOOK

We presented an extension of the teamwork factors model of Hoegl and Gemuenden [2] and proposed a study design for validating the extended model. We expect that results of this

study will give software development teams and their managers useful insights that can be used to build, manage, and contribute to teams more effectively.

To evaluate our assumption that trust, value diversity, and coordination of expertise contribute more to explaining project success than the factors of Hoegl and Gemuenden [2], the study should be conducted and the results should be compared to those of Hoegl and Gemuenden [2]. However, due to the influence of other factors, we do not expect to be able to approach a perfect explanatory model. Factors such as project planning [11], individual factors [28] organizational influences [29] and technical factors (such as project size, complexity, and duration) [30] may predict performance as well. These other factors should be subject of follow-up studies.

Further limitations and threats to validity include the self-selecting bias and the study being cross-sectional instead of longitudinal.

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