Teamwork Quality and the Success of Innovative Projects: A Theoretical Concept and Empirical Evidence

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Abstract

An extensive body of literature indicates the importance of teamwork to the success of innovative projects. This growing awareness, that "good teamwork" increases the success of innovative projects, raises new questions: What is teamwork, and how can it be measured? Why and how is teamwork related to the success of innovative projects? How strong is the relationship between teamwork and various measures of project success such as performance or team member satisfaction? This article develops a comprehensive concept of the collaboration in teams, called Teamwork Quality (TWQ). The six facets of the TWQ construct, i.e., communication, coordination, balance of member contributions, mutual support, effort, and cohesion, are specified. Hypotheses regarding the relationship between TWQ and project success are tested using data from 575 team members, team leaders, and managers of 145 German software teams. The results of the structural equation models estimated show that TWQ (as rated by team members) is significantly associated with team performance as rated by team members, team leaders, and team-external managers. However, the magnitude of the relationship between TWQ and team performance varies by the perspective of the performance rater, i.e., manager vs. team leader vs. team members. Furthermore, TWQ shows a strong association with team members' personal success (i.e., work satisfaction and learning).

(Teamwork; Innovation; Software Development)

The importance of teams to the success of innovation processes is well documented in the *theoretical* literature. Popular approaches to new product development (Johne and Snelson 1990, Clark and Fujimoto 1991, Cooper 1993) such as project management (Pinto et al. 1993, Fleming and Koppelman 1996, Gemuenden and Lechler 1997), speed and cycle time management (Gemuenden 1990, Eisenhardt and Tabrizi 1995), as well as total quality management and continuous improvement (Griffin and Hauser 1992, Lawler et al. 1995, Mohrman et al. 1995) consider *teamwork as a crucial success factor.*

Empirical evidence regarding the influence of teamwork on the success of teams with innovative tasks, however, is lacking in two ways. First, past research has often employed rather crude measures of *teamwork*, without adequately addressing the multifaceted nature of the functioning of teams (Denison et al. 1996). While many studies demonstrate the link between the *mere existence* of a team-based organization and innovative performance (Gupta et al. 1987, Hise et al. 1990, Cooper and Kleinschmidt 1995, Gupta and Wilemon 1996), they fail to specify and measure the collaborative work of teams and to illustrate how this relates to various aspects of the success of innovative projects. Second, existing empirical evidence regarding the impact of teamwork on the success of innovative projects is conflicting. As past studies report influences of varying magnitude on team members' ratings of performance, managerial ratings or other measures of innovative performance (e.g., number of ideas) seem less affected by the quality of teamwork (Thamhain and Kamm 1993, Campion et al. 1993, Campion et al. 1996, Cohen et al. 1996).

The present study aims to contribute to the clarification of these critical issues. In particular, it addresses the following questions: (1) What is "teamwork," and how can it be measured? (2) Why and how is teamwork related to the success of innovative projects? (3) How strong is the relationship between teamwork and different measures of project success? Thus, the primary contribution of this research is to provide a comprehensive understanding of

1047-7039/01/1204/0435/$05.00
1526-5455 electronic ISSN

teamwork quality, to develop a valid and reliable measure of this construct, and to test its influence on different aspects of project success using data from 575 interviews with members, leaders, and managers of 145 software development teams in Germany.

Teamwork Quality: A Measure of Collaboration in Teams

Following the literature, a team can be defined as a social system of three or more people, which is embedded in an organization (context), whose members perceive themselves as such and are perceived as members by others (identity), and who collaborate on a common task (teamwork) (Alderfer 1987, Hackman 1987, Wiendieck 1992, Guzzo and Shea 1992).

The many experienced managers who emphasize the merits of "good teamwork" have numerous behavioral requirements in mind. Their claims remain rather vague and meaningless, however, as long as the essence of a team, the quality of its collaborative working, is neither precisely defined nor validly and reliably measured. We advocate first developing theories that explain which aspects of teamwork are relevant to team performance and then testing these propositions to make distinctions that are useful for *practical* purposes (i.e., distinguishing between teams that achieve results and those that do not).

Following the work of Homans (1974) on the elementary forms of social behavior, we can conceptualize human behavior in teams as activities, interactions, and sentiments. *Activities* are observable actions of individuals that can be measured by quantity (e.g., the production output of a factory worker) as well as by the correctness of their execution (e.g., the effectiveness of an action). *Interaction* refers to the connectedness or the "being in contact" of two or more people regardless of the activities that bring them into contact. According to Homans (1974), interaction can be studied in terms of frequency and intensity. The third element of social behavior is *sentiment*, which refers to human emotions, motivations, or attitudes. Sentiments cannot be directly observed, but nevertheless influence interactions and activities and are, in turn, influenced by them.

The focus of this research is solely on the *quality of interactions within teams* rather than team members' (task) activities. Starting from the widespread fundamental proposition that the success of work conducted *in teams* depends (beyond the quantity and correctness of the task activities) on how well team members collaborate, or interact, we propose the construct *teamwork quality (TWQ)* as a comprehensive concept of the quality of interactions in teams. To capture the nature of team members' working together, we specify six facets of the collaborative team process that integrate to the concept of TWQ. These facets capture both task-related and social interaction within teams. The quality of interactions with external parties (e.g., management, other teams, etc.) is not part of the TWQ construct (Gladstein 1984, Ancona and Caldwell 1988, Ancona and Caldwell 1990). The six TWQ facets—communication, coordination, balance of member contributions, mutual support, effort, and cohesion—comprise *performance-relevant measures of team internal interaction*. Thus, the focal point is the quality of a team's collaborative work rather than the content of its tasks and activities (e.g., we are concerned with how well team members communicate task-relevant information, not with what their communication is about). Therefore, measures of the team-task process, such as the appropriateness of the task strategy employed (Hackman 1987, Denison et al. 1996) or the quality with which task activities are carried out by team members, are not the subject of the TWQ construct as we propose it. Furthermore, leadership processes including activities such as goal setting, task planning, resource acquisition and distribution, and task controlling, as well as feedback and performance appraisal, are not within the scope of the TWQ concept. These variables refer to the content of task activities rather than to the quality of interactions within teams. We do assume that there is a connection between many of the above-mentioned team-based task content and leadership activities such that high TWQ would facilitate the efficiency and effectiveness of the execution of these activities in a team setting; however, these possible relationships are not investigated in the present report.

Based on this understanding of interaction in teams, our review of the relevant literature and various exploratory empirical case studies conducted on this subject has resulted in six concepts that are descriptive of the quality of collaborative working in teams. The table below gives an overview of the six concepts included in the TWQ construct and the principal questions they address.

We conceptualize TWQ as a multifaceted higher order construct. The underlying proposition of this construct is that highly collaborative teams display behaviors related to all six TWQ facets. Thus, these six facets are indicators of the collaborative work process in teams and combine to the TWQ construct. This conceptualization as a higher order (latent) construct is comparable to Hackman's (1987) "process criteria of effectiveness" in that several critical indicators (or subconstructs) are combined in the specification of the team task process. The following is a discussion of the TWQ facets that provides a detailed

Table 1 The Teamwork Quality Construct

- *Communication*
  - Is there sufficiently frequent, informal, direct, and open communication?
- *Coordination*
  - Are individual efforts well structured and synchronized within the team?
- *Balance of Member Contributions*
  - Are all team members able to bring in their expertise to their full potential?
- *Mutual Support*
  - Do team members help and support each other in carrying out their tasks?
- *Effort*
  - Do team members exert all efforts to the team's tasks?
- *Cohesion*
  - Are team members motivated to maintain the team? Is there team spirit?

description of these concepts as they relate to the TWQ construct as a whole.

Communication

The most elementary component of TWQ is the communication within a team. Communication provides a means for the exchange of information among team members (Pinto and Pinto 1990). The quality of communication within a team can be described in terms of the frequency, formalization, structure, and openness of the information exchange. While *frequency* refers to how extensively team members communicate (i.e., time spent communicating), the *degree of formalization* describes how spontaneously team members are able to converse with each other. Communication that requires a large amount of preparation and planning before it can occur (e.g., scheduled meetings, written status reports) is considered more formal, whereas spontaneously initiated contacts (e.g., talks in the hallway, quick phone calls, short e-mails) constitute informal communication. It is this informal, spontaneous communication that has been shown to be crucial to the work of teams with innovative projects because ideas and contributions can be shared, discussed, and evaluated with other team members more quickly and efficiently (Katz 1982, Pinto and Pinto 1990, Brodbeck 1994, Domsch and Gerpott 1995). In addition, it is important to the quality of collaboration in teams that team members be able to communicate directly with all other team members (communication structure) because the exchange of information through mediators (e.g., team leader) is time consuming and a possible cause of faulty transmission. Apart from frequency, formalization, and structure, it is critical to TWQ that members share their information *openly* with each other (Gladstein 1984, Pinto and Pinto 1990). A lack of openness within a team (i.e., holding back important information) hinders the most fundamental function of teamwork, namely the integration of team members' knowledge and experience on their common task.

Coordination

The degree of common understanding regarding the interrelatedness and current status of individual contributions also determines the quality of teamwork performed. While teams must work together on fundamental aspects of a common task, many activities in the task process should be delegated to individual members working on parallel subtasks. One important component of the quality of collaboration in teams is the harmonization and synchronization of these individual contributions (Tannenbaum et al. 1992, Larson and Schaumann 1993, Brannick et al. 1995). To do this effectively and efficiently, teams need to agree on common work-down structures, schedules, budgets, and deliverables. Thus, coordination means that the teams have to develop and agree upon a common task-related goal structure that has sufficiently clear subgoals for each team member, free of gaps and overlaps.

Balance of Member Contributions

It is important to the quality of teamwork that every team member is able to contribute all task-relevant knowledge and experience to the team (Hackman 1987, Seers et al. 1995). This is especially critical for teams with innovative tasks because they often consist of members whose expertise is in different functional areas (e.g., R&D, marketing, finance, etc.). It would defeat the purpose of such cross-functional teams if some team members could not bring in their views and ideas because others were dominating discussions and decision-making processes. Therefore, it is considered essential to TWQ that contributions to the team task are balanced with respect to each member's specific knowledge and experience. While not everyone must bring in, for instance, the exact same number of ideas, no one should be limited in presenting and contributing relevant knowledge to the team.

Mutual Support

Building on the work of Tjosvold (1984, 1995), we find that mutual support among team members is an essential component of TWQ. The intensive collaboration of individuals depends upon a cooperative rather than a competitive frame of mind. Without questioning the motivational potential of competition in the case of independent

individual tasks, Tjosvold (1995) argues that, for interdependent tasks, mutual support is more productive than are the forces of competition. Thus, team members working on a common goal should display mutual respect, grant assistance when needed, and develop other team members' ideas and contributions rather than trying to outdo each other. Competitive behaviors in a team lead to distrust and frustration, whereas mutual support fosters the integration of team members' expertise and is, therefore, a critical aspect of the quality of collaboration in teams.

Effort

Norms are defined as shared expectations regarding the behavior of team members (Levine and Moreland 1990, Goodman et al. 1987, Helfert 1998). While such shared expectations can exist for every kind of observable behavior in teams, norms regarding the *effort* of team members are of particular importance to TWQ. Workload sharing and prioritizing of the team's task over other obligations are indicators for the effort team members exert on the common task (Hackman 1987, Pinto and Pinto 1990, Campion et al. 1993). To achieve high TWQ and avoid conflict among team members, it is important for everyone in the team to know and accept the work norms concerning sufficient effort. A uniformly high level of effort by all team members is primary to the quality of collaboration.

Cohesion

Team cohesion refers to the degree to which team members desire to remain on the team (Cartwright 1968). Several forces play a part in a person's desire to stick with the team. In their meta-analysis (including 49 empirical studies) Mullen and Copper (1994) distinguish between three forces of cohesion: (1) interpersonal attraction of team members, (2) commitment to the team task, and (3) group pride-team spirit. High TWQ can hardly be achieved without an adequate level of cohesion. If team members lack a sense of togetherness and belonging, if there is little desire to keep the team going, then intensive collaboration seems unlikely. An adequate level of cohesion is necessary to maintain a team, to engage in collaboration, and thus to build the basis for high TWQ.

Success of Innovative Projects

The conceptualization of project success as a multivariable construct is widely acknowledged in the literature (Gemuenden 1990, Pinto et al. 1993, Denison et al. 1996, Gemuenden and Lechler 1997, Hauschildt 1997). Many authors distinguish between task-related outcomes (e.g., quality, adherence to budget and schedule) and people-related outcomes (e.g., team member satisfaction, viability of the team). This distinction was adopted for the present study because the outcome categories *team performance* and the *personal success of team members* are considered separately.

Thus, our conceptualization of project team success (as well as the measurement model built on it) is following a consistent stream of team-success modeling, including Gladstein (1984), Hackman (1987), and models published since then (e.g. Sundstrom et al. 1990, Tannenbaum et al. 1992, Denison et al. 1996). The following table illustrates the relations between the conceptualization of project team success as applied in the present study with the approaches taken by Gladstein (1984), Hackman (1987), and Denison et al. (1996). As shown, our concept builds and expands on these three models.

Team Performance

Team performance can be defined as the extent to which a team is able to meet established quality and cost and time objectives (Gemuenden 1990, Schrader and Goepfert 1996, Gemuenden and Lechler 1997). The perception of project success depends, in part, on the perspective of the evaluator. Thus, it is important to include multiple views (e.g., of the company, the customer, the team) when rating team performance. It must also be acknowledged that setting clear and precise performance objectives at the outset of a project is particularly difficult in the case of innovations because the subject matter is often highly complex and uncertain (Gemuenden 1995, Hauschildt 1997).

For the purpose of the present study, team performance is described in terms of the variables effectiveness and efficiency. *Effectiveness* refers to the degree to which the team meets expectations regarding the *quality* of the outcome. In the case of innovative projects, an effective performance regularly entails adherence to predefined qualitative properties of the product, service, or process to be developed, e.g., functionality, robustness, reliability, performance, etc. The team's *efficiency* is assessed in terms of adherence to *schedules*, e.g., starting the manufacturing and/or marketing on the target date, and *budgets*, e.g., staying within target costs with both the project and the finished product. Thus, effectiveness reflects a comparison of actual versus intended outcomes, whereas efficiency ratings are based on a comparison of actual versus intended inputs.

Personal Success of Team Members

In addition to achieving performance objectives, teams must also work in a way that increases members' motivation and ability to engage in future teamwork (Hackman 1987, Sundstrom et al. 1990, Denison et al.

Table 2 Comparison of Team Success Conceptualizations

Present Study	Gladstein 1984	Hackman 1987	Denison et al. 1996
Effectiveness (Quality) Efficiency (Schedule and Budget)	Performance	Acceptability of output to those who receive/review it.	Information Creation Time Compression Overall Effectiveness
Work Satisfaction (personal satisfaction of team members; desire to work in teams in the future)	Satisfaction	Members' needs are more satisfied than frustrated by the group experience. Capability of members to work together in the future is strengthened.	Growth Satisfaction
Learning (acquisition of knowledge and skills)	—	—	Learning Capability Development

1996). For the purpose of this investigation, the two variables *satisfaction* and *learning* build the category *personal success of team members*. Satisfaction with working in teams leads to increased motivation for participating in future team projects. Also, collaborating with other people provides the opportunity for learning social, project management, technical, and creative skills. Such acquisition of new skills relates to team members' desire for personal and professional growth (Denison et al. 1996) as well as increasing the potential of the team members for future teamwork.

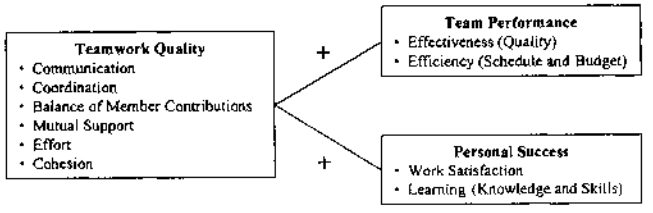
Hypotheses

It is the central proposition of this article that TWQ is positively related to the success of innovative projects.

Figure 1 depicts the two categories of project success (i.e., team performance and personal success of team members) as well as the proposed positive relationship with TWQ.

This conceptual framework constitutes a process-outcome model. In comparison to comprehensive input-process-outcome models of team effectiveness (Gladstein 1984, Hackman 1987, Tannenbaum et al. 1992), our model focuses on the collaborative work process (i.e., TWQ) and illustrates how this affects various team outcomes. As such, our research framework specifically addresses the "black box" of input-outcome models of team effectiveness (Guzzo and Shea 1992) and offers a comprehensive concept of team members' collaboration on their common task. Given this focus, however, possible antecedents of TWQ (i.e., inputs) are not investigated in this report.

Figure 1 Teamwork Quality and the Success of Innovative Projects



Teamwork Quality and Team Performance

TWQ is a measure for the quality of collaboration in teams and consists of six facets: communication, coordination, balance of member contributions, mutual support, effort, and cohesion. Building on the discussion of the TWQ construct above, we will present below the theoretical rationale as well as empirical evidence for the proposed positive relationship between TWQ and team performance on the basis of every TWQ facet.

Communication. It is widely agreed upon in the literature that the flow of communication within teams influences the success of innovative projects (Griffin and Hauser 1992). Research by Katz and Allen (1988), involving 50 R&D teams, demonstrates a strong positive impact of within-team communication on project success. More recent studies confirm this fundamental finding. Hauptman and Hirji (1996), in their investigation on 50 cross-functional project teams, show that frequent two-way communication within teams exerts a positive influence on team performance. In addition, a large-scale empirical study in Germany on the success factors of project management finds communication and information flow to be a direct prerequisite of project success (Gemuenden and Lechler 1997).

Coordination. Coordinating contributions from different functional areas efficiently is of critical importance to

the successful design and implementation of innovations. Teams can be seen as a mechanism for integrating various skills needed to perform complex and uncertain tasks successfully. From this perspective, teams provide a form of organization in which individuals with different expertise can collaborate directly on a task and, thus, achieve a very high degree of coordination among each other (Lawrence and Lorsch 1967, Nadler and Tushman 1988, Adler 1995). A study by Gupta et al. (1987), which includes 167 high tech companies in the United States, confirms this widely held opinion. Highly integrated companies use mainly teams (venture teams and temporary task forces) in their new product development.

Balance of Member Contributions. It is essential to the success of innovative projects that all team members feel free to bring in their task-relevant expertise. If discussions and decision making are dominated by some team members, and others in the team are unable to contribute their views and ideas, then this will have negative consequences on the team's performance (i.e., quality, costs, time) because *avoidable* mistakes are likely to be made. In his empirical study, Seers (1989) demonstrates that the balance of member contributions is significantly related to both task performance and team-member satisfaction.

Mutual Support. According to Tjosvold (1984, 1995), it is important for team members not to compete (e.g., for resources or prestige), but to cooperate to achieve a common goal. A laboratory study by Cooke and Szumal (1994), involving 64 groups of students, demonstrates that constructive-cooperative behaviors within teams (as opposed to aggressive interaction or passivity) increase both the quality and the acceptance of the solutions developed. It is further reasonable to assume that the level of mutual support impacts team performance through its influence on communication and coordination within teams.

Effort. The effort that team members exert on their common task influences the success of the project (Hackman 1987). This proposition reflects the fundamental assumption that, independent of other factors such as task-relevant knowledge and skills, the level of effort brought to bear on a task influences performance. A study by Weingart (1992) provides support for this proposition at the team level of analysis. The results from data of 56 student groups indicate that effort, among other variables such as planning and coordinating of tasks, has a significant influence on team performance.

Cohesion. Even though the empirical evidence of the influence of team cohesion on performance is not entirely conclusive (see Janis 1995 for the detrimental effects of the groupthink phenomenon in the case of very high levels of cohesion, particularly for longstanding groups), a number of recent reviews and empirical studies underline a positive relationship between the two. As one main result of their meta-analysis, including 49 empirical studies, Mullen and Copper (1994) report that it is chiefly the commitment to the task (as an indicator of cohesion) that shows a significant impact on team performance. Gully et al. (1995) include 51 effects of 46 empirical investigations in their meta-analysis and conclude that cohesion influences performance, particularly if the team task requires coordination and communication (e.g., innovative tasks). These results indicate that an *adequate level* of cohesion impacts the performance of innovation teams through its positive influence on communication and coordination.

The theoretical considerations and the evidence presented on the basis of the six TWQ facets result in the following hypothesis:

HYPOTHESIS 1. *TWQ is positively related to the performance of teams with innovative projects.*

Teamwork Quality and the Personal Success of Team Members

In addition to the positive relationship with team performance, TWQ is assumed to influence the personal success of team members. High TWQ leads to team members' satisfaction with their work situation and provides an opportunity for team members to acquire knowledge and skills. Recent empirical evidence provides support for this assumption. Research by Pinto et al. (1993), involving 72 task forces, shows that within-team cooperation influences both performance and team member satisfaction. These results are confirmed by the studies of Campion et al. (1993) and in a later replication by Campion et al. (1996). Both empirical investigations demonstrate strong relationships between measures of within-team cooperation and communication and the satisfaction of team members. In light of these theoretical considerations as well as of the empirical evidence, the following hypothesis is proposed:

HYPOTHESIS 2. *TWQ is positively related to the personal success of team members.*

Methods

Sample and Data Collection

A total of 145 software development teams from four German software development laboratories participated in this research. All four laboratories were part of larger organizations, with two of them being independent operations of the same U.S. parent company. The other two

laboratories belong to organizations headquartered in Germany. Each laboratory employed between 100 and 500 software developers. Included in the study were software development projects that were undertaken within 18 months prior to data collection and that were worked on by teams that met the above-described definition (i.e., three or more members, common identity). The first author was provided a list of projects, including names and contact information of team members, while the employees of the software laboratories were informed that a study about team management was to be conducted. All team leaders and team-external managers as well as randomly chosen team members were contacted for interview appointments. Respondents' participation in this study was strictly voluntary. All contacted respondents were interviewed.

Data were gathered by the first author and research assistants in individual interviews using a fully standardized questionnaire (five-point answer scale). All interviews were conducted on site in dedicated interview rooms which assured similar conditions for every interview. The interviews followed a very structured pattern. First, team membership as stated on the list was confirmed with the respondent to ensure that he or she was indeed a member of the team in question and to ascertain that all respondents of one team were referring to the same set of individuals as the team. Then the questionnaire was handed over for the respondent to complete by reading it himself or herself. This way, possible interviewer effects were minimized, while there was still an interviewer present to clarify questions if any occurred. The time consumption of one interview was about 45 minutes. A total of 575 interviews with members, leaders, and (team external) managers referring to 145 software development teams was conducted. Multiple respondents from each team, one of whom was the team leader, were interviewed to obtain more reliable ratings of the team level constructs in consideration. On average, three members of each team were interviewed. Of the team members, 22% were female. Our sample contains 26% female respondents. The teams in this sample have an average of 6.3 members (median = 6, standard deviation = 3) and an average age of all team members of 36.6 years (median = 36, standard deviation = 5).

Measures

All constructs considered in this investigation refer to the team as the unit of analysis. Accordingly, all measures were specified on the team level. Thus, respondents were asked to evaluate properties and behaviors of the team as a whole. The questionnaire was administered in the German language. All constructs investigated in this study were assessed using multiple questionnaire items. Translations of the items used in the following analyses are included in the appendix. A pretest was conducted, including 23 members of product development teams, at a machine tool manufacturing company. Following this pretest, the wording of some items was refined for later use in the present study.

The TWQ facets were measured using three to 10 items each. The items were specifically generated for the present study based on the discussions of these constructs in the literature (see the construct descriptions above). Some items used by Pinto et al. (1993) were translated to German for inclusion in the communication and mutual support scales. The discussions by Seers (1989) and Seers et al. (1995) gave guidance in generating the items for balance of member contributions.

The measurement scales for effectiveness and efficiency were based partly on the scales used by Gemuenden and Lechler (1997) in their large-scale study of project management in Germany. Effectiveness, i.e., the technical quality of the software solution, including the satisfaction with the software solution from different perspectives (customer, team), was measured using 10 items. Another five items were used for measuring the teams' adherence to schedule and budget (i.e., efficiency).

Team members' work satisfaction and learning were assessed using three and five items, respectively. The items for these scales were generated based on the discussions of the constructs by Hackman (1987), Sundstrom et al. (1990), and Denison et al. (1996). All measurement scales used in this study demonstrated strong reliability (Cronbach's alpha coefficients between 0.72 and 0.97).

To ensure content validity and avoid a possible common source bias, data from different respondents were used to measure the different variables. TWQ and team members' personal success were measured using aggregated responses from multiple team members (excluding team leaders). The team performance variables, however, were assessed from three perspectives. Team members, team leaders, and team-external managers were all asked to rate effectiveness and efficiency using the same measurement scales.

Explanatory statements made by managers during interviews and after the study suggest that their judgements were primarily reliant on customer feedback (once the software was in operation) for assessing quality and on project controlling reports for assessing budget and time performance. Some managers explained to us that they could offer a "bird's-eye view" of project results because they were not very familiar with how individual projects progressed (i.e., task process). Team members, in contrast, often explained that they were less familiar with

project controlling reports and often had less contact with the customer after the development project was completed. The team leaders, when asked by the interviewers, appeared well aware of both the "manager's world," i.e., project controlling reports and customer reactions, and the "team members' world," i.e., operational details about the task process. Thus, the three types of respondents (i.e., team members, team leaders, and managers) represent three different perspectives drawing on varying sources of information in their evaluations of team performance.

Prior to aggregating team members' evaluations, interrater agreement (James 1982, James et al. 1984, Campion et al. 1993) was assessed using the multiple-item estimator for within-group interrater reliability as proposed by James et al. (1984). This test yielded results indicating generally very strong agreement of ratings referring to the same team. The average scores of this test across all teams are included in the table below for the applicable constructs (i.e., team member ratings of TWQ, team performance, and personal success). Given this homogeneity of within-team ratings, data were aggregated by calculating the arithmetic mean.

The database for this empirical study includes teams from four different software development laboratories. Prior to combining the data, the samples were tested for possible differences in means. The one-way ANOVA yielded significant results ($p < 0.01$) only for effectiveness as rated by the team leaders (Effectiveness-TL). Further t-tests revealed that Laboratory 2 and 3 showed significantly different means for this variable. Apart from this, the four samples showed generally strong homogeneity in both means and variances for all variables investigated in this study.

Data Analysis

Teamwork Quality as a Higher Order Construct. Factor analyses were conducted to assess whether all six specified TWQ facets pertain to the same latent construct. First, we conducted a factor analysis (principle-component method) on the team level using aggregated team member responses. The results confirm the latent construct assumption concerning the TWQ construct. Following the Kaiser criterion, the one-factor solution can be accepted because the eigenvalue of the second component falls far below one. All six facets are loading high

Table 3 Number of Items, Means, Standard Deviations, Reliabilities, and Intercorrelations

	Items	Mean	SD	Alpha[b]	IRR[c]	1	2	3	4	5	6	7	8	9	10	11	12	13
TWQ[a]																		
(1) Communication	10	4.20	0.44	0.94	0.95													
(2) Coordination	4	4.04	0.59	0.85	0.79	0.58												
(3) Balance of Member Cont.	3	4.08	0.50	0.72	0.84	0.73	0.54											
(4) Mutual Support	7	4.13	0.55	0.93	0.93	0.80	0.55	0.75										
(5) Effort	4	3.91	0.59	0.94	0.88	0.61	0.52	0.65	0.62									
(6) Cohesion	10	3.89	0.56	0.97	0.94	0.69	0.49	0.74	0.75	0.78								
Team Performance (Team Member Rating)																		
(7) Effectiveness-TM	10	3.91	0.59	0.91	0.96	0.41	0.39	0.45	0.44	0.36	0.42							
(8) Efficiency-TM	5	3.76	0.77	0.86	0.91	0.36	0.28	0.38	0.42	0.34	0.38	0.64						
Team Performance (Team Leader Rating)																		
(9) Effectiveness-TL	10	4.11	0.55	0.90	—	0.20	0.25	0.19	0.18	0.20	0.19	0.54	0.32					
(10) Efficiency-TL	5	3.93	0.78	0.86	—	0.17	0.21	0.23	0.19	0.24	0.24	0.33	0.51	0.58				
Team Performance (Manager Rating)																		
(11) Effectiveness-Mgr	10	4.11	0.62	0.87	—	0.22	0.22	0.15	0.18	0.14	0.15	0.37	0.20	0.40	0.24			
(12) Efficiency-Mgr	5	3.96	0.85	0.85	—	0.17	0.10	0.16	0.17	0.18	0.19	0.17	0.37	0.30	0.47	0.61		
Personal Success of Team Members[a]																		
(13) Work Satisfaction	3	4.01	0.55	0.79	0.86	0.68	0.51	0.72	0.73	0.60	0.77	0.62	0.48	0.34	0.24	0.24	0.18	
(14) Learning	5	4.06	0.46	0.76	0.92	0.48	0.34	0.49	0.52	0.51	0.65	0.38	0.31	0.13	0.08	0.07	−0.01	0.64

[a] = team member ratings
[b] = cronbach's alpha coefficient
[c] = coefficient of interrater reliability (James et al. 1984)

on one factor. The factor TWQ explains 71.51 % of the variance of the six scales.

To ensure that the results obtained at the team level ($N = 145$) are not the result of inflated correlations due to data aggregation, we have conducted further factor analyses at the individual level ($N = 285$). In doing so, possible dependencies of observations within one team must be dealt with. We have employed two procedures to test the TWQ factor structure at the individual level. First, we have randomly sampled 145 responses and conducted factor analyses. This process was repeated 15 times. All individual-level factor analyses support the team-level findings. All analyses resulted in the extraction of one factor using the Kaiser criterion. Second, to test the factor structure at the individual level including all 285 responses, we have regressed group on every TWQ facet index and saved the standardized residuals for further analysis. We have used the standardized residuals from this procedure ("purified" from group effect) as input for another factor analysis including all 285 team member responses. The results again confirm the team-level factor analysis. One factor was extracted using the Kaiser criterion.

Furthermore, we followed the procedures suggested by Henik and Tzelgov (1985) to control for a possible halo effect whereby team members' general sense of their team's success may have caused them to give correlated ratings across the TWQ facets. We have regressed the first item of the effectiveness scale as a general indicator of project success ("Going by the results, this project can be regarded as successful") on the standardized residuals from the group effect procedure above. The standardized residuals ("purified" from halo effect) were saved and used as input for another factor analysis at the individual level ($N = 285$). Again, a one-factor solution for the six TWQ facets emerged, indicating that the six TWQ facets pertain to the same latent construct.

The following table shows the loadings of the team-level factor analysis as well as the standardized regression coefficients of a linear regression with the (aggregated) TWQ construct as the dependent variable.

Structural Equation Modeling. Structural equation modeling was the principal analytic technique employed in this study. Using the statistical software package AMOS, version 4.0, structural equation modeling (SEM) allows simultaneous testing of the measurement and structural models. Analyses were conducted using the unweighted-least-squares method (ULS). To reduce the number of free parameters in the model (to be appropriate given the number of cases; $N = 145$ teams) (Bagozzi and Yi 1988), the multiple-item scales were each aggregated by calculating the arithmetic mean and treated as observed indicators in the model. The error variances of the scales were left unspecified in the SEMs. Detailed statistics for these scales are provided in Table 3.

Table 4 Teamwork Quality as a Higher Order Construct: Factor Analysis, Regression Analysis, Reliability Analysis

TWQ Facet	Factor Loading	Std. Regr. Coefficients	*P*-Value
Communication	0.88	0.16	0.00
Coordination	0.71	0.22	0.00
Balance of Member Contributions	0.89	0.19	0.00
Mutual Support	0.89	0.20	0.00
Effort	0.82	0.22	0.00
Cohesion	0.89	0.20	0.00
Eigenvalue	4.29		R^2 100%
Variance explained (Factor TWQ)	71.51%	Cronbach's alpha coefficient	0.91

Note. $N = 145$.

Results

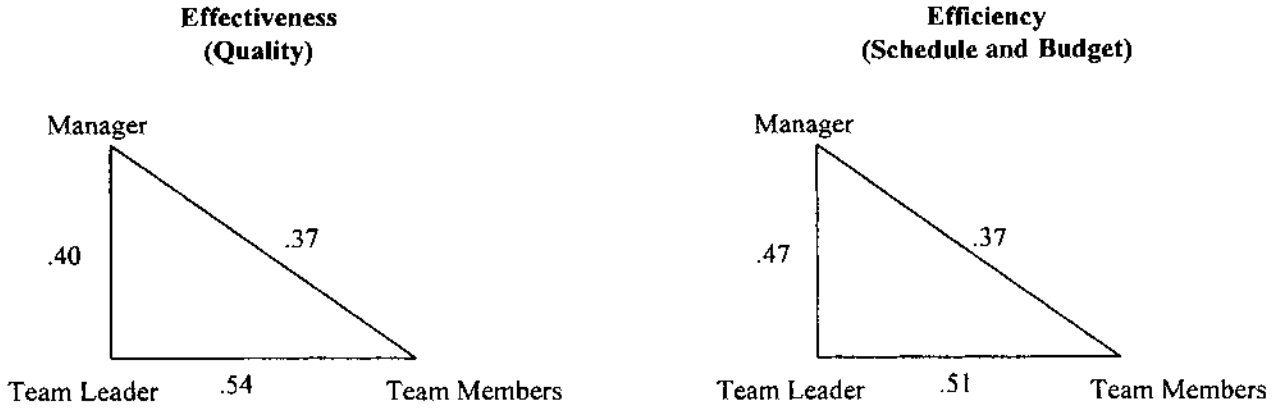
Team Performance from Different Perspectives

Gathering data concerning team performance from different perspectives makes it possible to analyze whether managers, team leaders, and team members experience project success in the same way. While comparisons of mean ratings do not yield any major differences between these three perspectives (all three parties rate all teams similarly on average; see Table 3), the correlations between the three ratings reveal agreement of varying magnitude.

Although the differences in correlations are not statistically significant, the results in Figure 2 display a common pattern underlying both effectiveness and efficiency ratings. While there is considerable agreement ($r > 0.50$) between the people that worked together on the project (team leader and team members), as well as reasonably strong coherence ($r > 0.40$) between team leaders and managers, there is less of a relationship ($r > 0.35$) between manager judgments and team members' evaluations of performance.

There are a number of possible reasons for these discrepancies (Gemuenden 1990). According to Hauschildt (1997), these differences in perceived success may be attributed to certain properties of the rater as well as to deviations in the reference criterion. As described above,

Figure 2 Correlations Between Performance Evaluations from Different Perspectives



Note. Correlations are significant at the .01 level (2-tailed).

managers and team members particularly seemed to have quite different sources of knowledge concerning the outcomes of individual projects. While team members were primarily familiar with the details of the software product and the course of the project, managers appeared to rely on data from project controlling reports and information from customer contacts in judging team performance. The team leaders seem to stand right in between the managers and the other team members, which could indicate that they are to some degree familiar with the experiences and realities of both parties.

Furthermore, managers' more distant observation of individual projects and their outcomes ("bird's-eye view"), could suggest that some managers may have been lacking detailed information about the relevant performance measures (quality, schedule, budget). Also, managers' and team leaders' ratings may have been influenced by perceptions of the overall success of the larger development endeavor or customer relationship to which a particular project team was contributing. Moreover, it is possible that managers, perhaps lacking better knowledge of actual performance, evaluate the outcomes based on their general impression of the expertise of the team leader or other team members, rather than solely considering actual performance.

Teamwork Quality and the Success of Innovative Projects

In testing our hypotheses we have estimated three structural equation models based on the three different project success ratings. Model 1: TWQ (evaluated by team members) predicts team members' (self-)evaluations of team performance and personal success. Model 2: TWQ (evaluated by team members) predicts team leaders' evaluations of team performance. Model 3: TWQ (evaluated by team members) predicts managers' evaluations of team performance. Details of the three models, including factor loadings, standardized coefficients, variance explained (R-square), and goodness-of-fit measures (GFI, AGFI, RMR, Chi-Square, Degrees of Freedom, P-Value) (Bagozzi and Yi 1988), are documented in Table 5. The results for the three models indicate strong overall model fit with the adjusted goodness-of-fit indicators at 0.99. All effects are significant on the 1% level.

The results of the three models estimated provide support to Hypothesis 1, proposing a positive influence of TWQ on team performance. The path coefficients from TWQ to team performance are significant on the 1% level in all three models. However, there are considerable differences in the magnitude of the relationship between TWQ and team performance as rated by the team members versus team leaders and managers. TWQ explains about 41% of the variance in team performance as rated by the team members, 11% as rated by the team leaders, and 7% as rated by the managers.

These differences may be attributed to the above-discussed suboptimal agreement between managers, team leaders, and team members on team performance. Another possible explanation is known as implicit theories (Gladstein 1984). According to this concept, team members, in light of the TWQ experienced, attribute good performance to (in their view) good team processes (Model 1). Furthermore, the relationships in Model 1 may be inflated due to common source bias, given that both TWQ and the project success constructs are based on team member data. In contrast, manager evaluations of team performance are much less likely to be influenced by implicit theories, given their limited knowledge of the collaborative task processes of individual teams. Additionally, the results of Models 2 and 3 are not subject to

Table 5 Structural Equation Models

	Model 1. TWQ Predicting Team Members' Evaluations of Team Performance and Personal Success		Model 2. TWQ Predicting Team Leaders' Evaluations of Team Performance		Model 3. TWQ Predicting Managers' Evaluations of Team Performance	
	Stand. Factor Loading	Stand. Coefficient/ *R*-Square	Stand. Factor Loading	Stand. Coefficient/ *R*-Square	Stand. Factor Loading	Stand. Coefficient/ *R*-Square
Teamwork Quality (TWQ)						
Communication	0.82		0.83		0.85	
Coordination	0.63		0.65		0.63	
Balance of Member Contr.	0.84		0.85		0.84	
Mutual Support	0.86		0.85		0.86	
Effort	0.76		0.79		0.79	
Cohesion	0.88		0.88		0.88	
Team Performance		0.64/0.41		0.34/0.11		0.26/0.07
Effectiveness (Quality)	0.86		0.74		0.80	
Efficiency (Schedule and Budget)	0.74		0.79		0.76	
Personal Success of Team Members		0.93/0.87				
Work Satisfaction	0.94					
Learning	0.69					
GFI (Goodness-of-Fit Index)		0.995		0.996		0.997
AGFI (Adjusted GFI)		0.992		0.993		0.994
RMR (Root Mean Square Residual)		0.013		0.012		0.010
Chi-Square		92.05		46.64		48.93
Degrees of Freedom		33		19		19
P-Value		<0.01		<0.01		<0.01

Note. $N = 145$; TWQ is based on aggregated team member evaluations (excl. team leaders) in all three models. All path coefficients are significant at the 0.01 level.

common source bias, as team leaders' and managers' evaluations of team performance are predicted by team members' evaluations of TWQ.

While recognizing the differences in the extent of the relationships given the different performance evaluations, Hypothesis 1 is supported because TWQ is significantly associated with all ratings of team performance.

The results of Model 1 provide strong support for Hypothesis 2. TWQ shows a very strong association with team members' personal success (standard coefficient 0.93, 87% variance explained). The results indicate that the quality of collaboration in a team determines the contentment of team members with their work situation to a large degree. Also, high TWQ fosters learning on the part of the team members, which accommodates the desire for personal and professional growth of the generally highly educated workforce of software development laboratories.

Discussion

This research yields several findings. (1) The quality of collaboration in teams can be captured through the six facets of TWQ. (2) TWQ shows a relationship with the success of innovative projects as measured by team performance (effectiveness and efficiency) and by the personal success of team members (satisfaction and learning). (3) The magnitude of the relationship between TWQ and team performance varies with the perspective of the rater (team member versus team leader versus manager).

Our findings support the conceptualization of TWQ as a higher order latent construct, as the six facets loaded on one factor in both the team- and individual-level factor analysis. The TWQ construct provides a comprehensive measure of the collaborative team-task process focusing on the quality of interactions rather than on activities in teams (Homans 1974). Thus, TWQ complements other elements of the team-task process, such as the task strategy

employed, (Hackman 1987) and the teams' external relations (Gladstein 1984; Ancona and Caldwell 1988, 1990).

The empirical results of this research document that TWQ is significantly related to project success (including team performance and team members' personal success). These findings on the basis of data from 145 software-development teams in Germany confirm prior studies in the United States, relating individual aspects of TWQ, such as mutual support (Pinto et al. 1993), balance of member contributions (Seers 1989), and team effort (Campion et al. 1993, Campion et al. 1996) to task- and people-related outcomes. Furthermore, our findings relate to previous research on software-development teams in Germany showing a positive relationship between informal communication and team performance (Brodbeck 1994). While our results do not allow us to draw inferences across cultural contexts, the consistency of findings of different studies in both countries seems to indicate some cross-national robustness of these relationships.

This research contributes to clarifying *how* teamwork relates to different measures of project success. Both team performance (effectiveness and efficiency) and the personal success of team members (satisfaction and learning) are significantly connected to TWQ. Thus, the TWQ construct offers a way to assess the quality of collaboration within teams and to actively influence this critical success factor by focusing management activities on improving the six TWQ facets (Hoegl 1998). It is worth noting that all six TWQ facets, when considered individually, display rather uniform relationships with the respective ratings of team performance. The correlations of the six facets with the evaluations of effectiveness and efficiency document homogeneous associations (for each rater) without showing any of the TWQ facets significantly deviating (see Table 3).

TWQ explains about 41% of the variance in team performance based on team member ratings. As this documents the explanatory power of TWQ, it leaves a bigger portion of the variance in team performance unexplained. Obviously, TWQ as a measure of the quality of collaboration cannot account for team performance entirely (Gemuenden and Hoegl 1998). Other aspects of project management, such as correct planning and controlling of the project, the existence and application of the necessary skills to do the job (Hackman 1987), the interaction between the team and its main constituencies (e.g., management, customer, other projects) (Gladstein 1984, Ancona and Caldwell 1988, 1990), and various influences from the organizational context (e.g., resource scarcity, organization structure) (Tannenbaum et al. 1992), may be important predictors of performance as well.

The results of this study indicate that there are considerable differences in the way in which team members, team leaders, and managers experience and, thus, rate team performance. This is an issue of great importance. If consequences (career development, financial bonus, etc.) are to be attached to certain performance levels, it is necessary to reach consensus among the parties involved regarding targeted and actual performance. It seems possible that factors on the organizational level, such as vertical and horizontal differentiation, could help to explain discrepancies in performance ratings. In an organization with a wide span of control, managers might have less in-depth knowledge of any particular project. Further inquiry into this phenomenon seems essential if teams are to be managed by objectives as well as rewards.

A few limitations of this study should be noted. First, the data for this research are cross-sectional rather than longitudinal. While our study demonstrates associations between variables, it cannot establish causality. A longitudinal research design using multiple informants would further our knowledge toward both causality of relationships and the development of team collaboration and team success perceptions over time. Second, the scope of the empirical data gathered for this research allows generalization of the results obtained chiefly to the domain of teams with innovative tasks, such as R&D teams, new venture teams, etc. Because innovative tasks are highly complex and dynamic, they require that a wide range of skills be closely integrated to achieve high effectiveness and efficiency. It is this integrative function that teams with innovative tasks must fulfill, and TWQ can be seen as a measure of just how well this is done. Therefore, we believe that as tasks get more innovative, TWQ becomes increasingly important to team performance. Hence, when tasks are routine (and even R&D teams sometimes have projects that pose modest levels of uncertainty and complexity), the quality of teamwork may have less effect on performance, while other factors such as external team relations, the organizational context, and process know-how become more important. Because our study was aimed at developing concepts specific to a defined domain of teams, we encourage empirical research that further increases our understanding of possible moderating effects, such as the influence of task characteristics on the relationship between TWQ and team performance.

Perhaps the most important issue for further research derives from the effect of TWQ on project success. Because this research provides empirical evidence that TWQ is an important success factor of innovative proj-

ects, it seems necessary to ask about the major antecedents of TWQ. What can managers of innovative projects do to encourage their teams to practice high TWQ? Existing theoretical models of team effectiveness (McGrath 1964, Gladstein 1984, Hackman 1987, Shea and Guzzo 1987, Sundstrom et al. 1990, Tannenbaum et al. 1992) provide a valuable starting point for necessary empirical research in this area.

Acknowledgments

The authors would like to thank the Editor as well as the three anonymous reviewers for their helpful comments.

Appendix

Construct	Variable (Items)
Teamwork Quality (TWQ)	*Communication.* There was frequent communication within the team. The team members communicated often in spontaneous meetings, phone conversations, etc. The team members communicated mostly directly and personally with each other. There were mediators through whom much communication was conducted.[R] Project-relevant information was shared openly by all team members. Important information was kept away from other team members in certain situations.[R] In our team there were conflicts regarding the openness of the information flow.[R] The team members were happy with the timeliness in which they received information from other team members. The team members were happy with the precision of the information received from other team members. The team members were happy with the usefulness of the information received from other team members.
	Coordination. The work done on subtasks within the project was closely harmonized. There were clear and fully comprehended goals for subtasks within our team. The goals for subtasks were accepted by all team members. There were conflicting interests in our team regarding subtasks/subgoals.[R]
	Balance of Member Contributions. The team recognized the specific potentials (strengths and weaknesses) of individual team members. The team members were contributing to the achievement of the team's goals in accordance with their specific potential. Imbalance of member contributions caused conflicts in our team.[R]
	Mutual Support. The team members helped and supported each other as best they could. If conflicts came up, they were easily and quickly resolved. Discussions and controversies were conducted constructively. Suggestions and contributions of team members were respected. Suggestions and contributions of team members were discussed and further developed. Our team was able to reach consensus regarding important issues.
	Effort. Every team member fully pushed the project. Every team member made the project their highest priority. Our team put much effort into the project. There were conflicts regarding the effort that team members put into the project.[R]
	Cohesion. It was important to the members of our team to be part of this project. The team did not see anything special in this project.[R] The team members were strongly attached to this project. The project was important to our team. All members were fully integrated in our team. There were many personal conflicts in our team.[R] There was personal attraction between the members of our team. Our team was sticking together. The members of our team felt proud to be part of the team. Every team member felt responsible for maintaining and protecting the team.
Team Performance	*Effectiveness.* Going by the results, this project can be regarded as successful. All demands of the customers have been satisfied. From the company's perspective, all project goals were achieved. The performance of our team advanced our image to the customer. The project result was of high quality. The customer was satisfied with the quality of the project result. The team was satisfied with the project result. The product required little rework. The product proved to be stable in operation. The product proved to be robust in operation.
	Efficiency. From the company's perspective one could be satisfied with how the project progressed. Overall, the project was done in a cost-efficient way. Overall, the project was done in a time-efficient way. The project was within schedule. The project was within budget.
Personal Success	*Work Satisfaction.* After this project, the team members could draw a positive balance for themselves overall. The team members have gained from the collaborative project. The team members would like to do this type of collaborative work again.
	Learning. We were able to acquire important know-how through this project. We see this project as a technical success. Our team learned important lessons from this project. Teamwork promotes one personally. Teamwork promotes one professionally.

[R] = reverse coded item

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Accepted by M. Scott Poole