Teamwork in Integrated Design Projects: Understanding the Effects of Trust, Conflict, and Collaboration on Performance

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ABSTRACT

Teamwork during integrated design projects is complex. We address this by investigating how trust, collaboration, and conflict evolve over time to affect performance. Our results stem from data gathered using validated self-report questionnaires with 38 participants in 5 multidisciplinary teams at three points in time during a 6-week integrated design competition. Results show that without collaboration, trust and conflict have no bearing on performance. In addition to an unambiguous practical outcome—fostering collaboration helps build trust and manage conflict—our study points to theoretical developments: as trust- and conflict-performance relations grow over time, so does collaboration’s mediating effect.

KEYWORDS: teamwork; collaboration; trust; conflict; projects; IRNOP 2011

INTRODUCTION

Transitions from one paradigm of practice to another are unlikely to be achieved without difficulty. Moving from one level to another requires the production and assimilation of new types of knowledge to support execution of activities and tasks. . . . A range of new skills, outlooks and resources are required.

(Blackler, Crump, & McDonald, 1999, p. 26)

Sustainable Development and Integrated Design in the Construction Industry

The concept of sustainable development was formalized in the late 1980s by the Brundtland Commission in a report to the United Nations as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (1987, p. 8). It stems from a paradigmatic shift initiated in the 1960s when problems associated with exponential population growth shattered the notion that energy was cheap and limitless (Krygiel & Nies, 2008). Tellingly, the construction industry is the one consuming the most energy and primary resources and creating the most waste (Keeler & Burke, 2009). For instance, buildings are designed as consumables, with an expected lifespan averaging around 30 (North America) or 50 years (Europe to be demolished afterward [Mendler, Odell, & Lazarus, 2006]). As sustainable development is making its way into the construction industry, buyers’ preferences for acquiring buildings that cost less to manage and maintain are creating competitive pressure on the construction industry to adopt sustainable development design and construction practices (Egan, 1998; Latham, 1994). In turn, the construction industry faces important challenges in integrating the complex work practices conducive to sustainable development (Larsson, 2002). In summary, heightened competition and increased complexity of buildings are “forcing design professionals to improve their processes in terms of time and quality” (Pektas & Pultar, 2006, p. 99).

We address this problem by applying team development theories and project management concepts to understand issues incurred by integrated design project teams. Integrated design project teams’ potential benefit—as well as its biggest challenge—revolves around managing design tasks across
architecture, engineering, and construction disciplines. We focus on trust, task conflict, and collaboration as they impact team members’ perceptions of team effectiveness across time. After exposing in detail the impetus for integrated design teams, we present relevant theories and empirical data drawn from the fields of design, work and organizational psychology, and project management. This serves as the conceptual footing on which we base our method and describe our results. We conclude by framing the role of collaboration as a key mechanism to integrated design teams’ effectiveness. Practical implications for these teams, as well as suggestions for additional theoretical work, conclude this article.

Designing a more sustainably built environment, which requires new ways of thinking, comes in sharp contrast to the processes by which buildings are usually designed. Although complex, designing and delivering a building is based on an artisanship model that has barely evolved in the last centuries, the process is characterized by several particularities. The client buys a product that has yet to be defined. Each building is different, and its design and construction are unique. The design and construction are done by a coalition of firms assembled temporarily for that specific project. Work is organized based on a guild structure of different specialties that are mutually exclusive yet temporally and functionally interdependent. As opposed to traditional organizational structure, power and roles within guilds are based on ability, knowledge, and mastery of appropriate rules defined by their professional bodies. For example, the architect will first define the aesthetic and the space configuration of the building; the engineers will then articulate the structural, mechanical, electrical, and plumbing systems. The design deliverables of each specialty (e.g., technical drawings and specifications) are prepared separately and assembled at the end in order to initiate the construction process. Finally, stakeholders and specialists work separately and often change from one project phase to another.

Sustainable development challenges this linear process in several ways—by dramatically increasing the complexity of decisions that must now be made, and the long-term impact of social, ecological, and economic consequences (Brundtland, 1987). This major transformation must be accompanied by equally profound changes in how work is organized and interdependency managed between actors from different disciplines, professions, and firms (Reed et al., 2009).

Integrated design is a response to this challenge. Integrated design is an interdisciplinary participatory process bringing together specialists and key stakeholders during intensive work sessions—the number of which depends on the type of project, its size, and its complexity—in order to collectively resolve multifaceted, ill-defined, and intertwined design and construction problems. Such decision-making work sessions evolved from “design charrettes,” an École des Beaux-Arts activity, where students in architecture had to design a complex project within a very short time frame. In the 1980s, charrettes were used to involve local citizens in the development of their communities. In the following decade, the concept of integrated design took shape with the introduction of rating systems for designing green buildings (Mendler et al., 2006).

Problems and Challenges of Integrated Design Teams

Although integrated design offers the promise of a more efficient process (i.e., avoiding construction rework because concerns are integrated in the design phase; Arditi & Günaydın, 1998) and a better project outcome, its process is more challenging. Three obstacles stand out. First, the common practice is that the client assembles a coalition of firms from various disciplines using transactional contracting. In a transaction, the seller must deliver a specified outcome to the buyer for an agreed-upon price. Risk and responsibility for results rest on the shoulder of the seller, who has no incentive for collaboration with other contract parties in determining the solution that will best meet expected results. It also makes each design professional liable for the results in his or her own specialty. Consequently, there is a lack of shared leadership and accountability for the overall project outcome (Dupagne, 1991). Koskela, Howell, and Lichtig (2006) contend that the incapacity of the industry to move from sequential to integrated design results from the adversarial business context created by transactional contracting methods.

Second, the configuration of work into functional and disciplinary areas negatively impacts the collaborative process. Collaboration is impeded because integrated design team members come from different organizations or practices and duplicate each other’s efforts, and many problems often fail to be resolved either quickly or to anyone’s satisfaction (Zager, 2002). Sequential and fragmented design is deeply rooted in professional codes of practice and bodies of knowledge. Professional associations maintain tight boundaries between business, design, and construction knowledge. They create epistemic barriers that compromise the successful resolution of conflicts or contradictions resulting from collaborative work (Brown & Duguid, 2001). For example, a transition to analysis-heavy
engineering programs lacking a design component in the 1950s and 1960s resulted in engineers less equipped to look at the entire problem and solve real-world problems (Gruenther, Bailey, Wilson, Plucker, & Hashmi, 2009). These authors add that “engineering design is a core knowledge area for all disciplines within engineering; it is not known exactly what engineering graduates know about design and where they learn it” (p. 721). Furthermore, architecture is the dominant practice in a sequential design and delivery process, and the architect its most powerful actor (Lawson, 2005). Lawson added that the perception of design being the result of one individual creative act is rooted in architecture training and deeply embedded in their practice, knowledge, and tools.

The third barrier is more complex. Compounded by the adversarial business context and interdisciplinary barriers are a number of behavioral issues that create friction among integrated design team members. Sharing knowledge necessitates learning how to behave under the new context of interdisciplinary teams, learning new roles and skills, and unlearning old habits and behaviors (Newstetter & McCracken, 2001). It also requires growth in the team’s capacity to manage itself as a unit, and to acquire, share, and use knowledge to make effective decisions (Druskat & Kayes, 2000).

Whereas traditional management of design teams is based on a “command and control” style—a style based on authorities directing activities of others using surveillance linked to incentives and sanctions (Tyler, 2003)—integrated design teams strive to flatten the decision-making structure. The architect’s role in an integrated design process must evolve from a hierarchically inclined decision maker to a role of mediator and problem solver. Instead of providing rigid solutions to architectural demands, engineers must learn to inject their knowledge and skills earlier in the design process.

These issues raise important questions: How can we help integrated design teams become more efficient? What is the effect of trust and conflict on team effectiveness? Can collaborative processes boost trust’s effect and alleviate conflict’s effect? When do trust, conflict, and collaboration occur in the team’s life cycle?

**Industrial, Work, and Organizational Psychology**

Scholars in the field of industrial, work, and organizational psychology have heavily researched team effectiveness, team processes, trust, and conflict for decades. Although a literature review of such a large body of knowledge is beyond the confines of this article, an overview is nonetheless necessary. This overview will lead to testable hypotheses specific to the problems of integrated design outlined earlier.

**Foundations: Team Development**

Although most are familiar with Tuckman’s (1965) stage model of team development (i.e., forming, storming, norming, performing, and adjourning; see Tuckman & Jensen, 1977), it is criticized for leaving several applied and theoretical questions unanswered (Chiocchio, 2009a). A number of other more contemporary and nuanced models exist (see Koslowski, Gully, Nason, & Smith, 1999, for a review). Three stand out: the Theory of Compilation (Kozlowski et al., 1999), the Transition–Action model (Marks, Mathieu, & Zaccaro, 2001), and the Input-Mediator-Output-Input (IMO) model (Ilgen, Hollenbeck, Johnson, & Jundt, 2005). These three theoretical models of team development share a number of characteristics. First, they distinguish between taskwork and teamwork (Marks et al., 2001). Taskwork is an individual-level construct. It represents how individual team members interact with tasks, tools, machines, and systems. Teamwork is a team-level construct corresponding to how team members work to combine their thoughts, actions, and feelings to coordinate and adapt, and to reach a common goal. Second, these models distinguish between individual states, emergent states, and team processes. Individual states are attitudes, values, cognitions, and motivations held by a person, such as self-confidence (Marks et al., 2001). Emergent states are team-level phenomena indicative of members’ individual states that develop over the life of the team (Ilgen et al., 2005; Kozlowski & Klein, 2000). A good example of an emergent state is intrateam trust. Intrateam trust reflects the team members’ perception of groupwide trust, expectations of truthfulness, and their sense of shared respect for group members’ competence (Simons & Peterson, 2000). Team processes are “members’ interdependent acts that convert inputs to outcomes through cognitive, verbal, and behavioral activities directed toward organizing taskwork to achieve collective goals” (Marks et al., 2001, p. 357). The building industry is particularly sensitive to problems with processes. Team efficiency problems increase waste and rework in architectural building design management (Rounce, 1998). Rounce added that “the competitive edge in the building industry depends on the quality of the process” (p. 201). Notably, processes predict team performance (Kozlowski & Bell, 2003; Lepine, Piccolo, Jackson, Mathieu, & Saul, 2008).

Collaboration—what people do together to achieve a collective goal—is an example of a positive process (Bedwell et al., 2009; Chiocchio, 2009b). Another example of a process is intrateam conflict (Williams & Allen, 2008). Conflict is the team’s awareness of discrepancies, incompatible wishes, or irreconcilable desires (Boulding, 1963, cited in Jehn & Mannix, 2001, p. 238) and what they do because of them (Tjosvold, 2008). There is a debate about whether conflict is a positive or a negative process affecting performance. We will discuss this issue later.

**The Importance of Collaboration**

Management problems, lack of coordination, and communication issues
interfere with successful design projects and extend design time (Rounce, 1998). In fact, Pektas and Pultar state, “The architecture/engineering/construction (AEC) industry is one of the multidisciplinary domains in which collaboration among related parties is of utmost importance” (2006, p. 99). Generic factors such as teamwork are important drivers of the quality of processes of design and construction projects, but industry-specific success drivers during the design process include design cooperation, communication with the owner, and the feedback system (Arditi & Günaydın, 1998). Arditi and Günaydın added that “cooperation lies in the improved communication” and “lack of cooperation may result in inconsistent design, which then may cost extra time and money throughout the construction process” (1998, p. 198). Lack of clarity in describing objectives or requirements, lack of coordination of roles and responsibilities at project inception, poor communication between designers, and problems coordinating between disciplines later on are well-known issues (Rounce, 1998). Design scholars Kim and Maher (2008) emphasized that designers involved in collaboration spend a great deal of time on “cognitive synchronization” (p. 226) characterized by rich bidirectional communication, such as asking for clarifications and analyzing the problem, in order to gain a shared understanding of the design solution.

These issues with communication, synchronicity, and coordination point to important procedural challenges that are not necessarily easy to define beyond descriptive accounts. Pextasx and Pultar define the collaborative building design process “as an iterative flow of interdependent decisions of different design professionals” (2006, p. 100). This description highlights the cognitive dynamics involved between team members across time. However, it leaves unanswered the questions of how to manage the flow of decisions and how to manage the flow of interdependent actions that define the design task across disciplines. In other words, a better definition of collaboration is required.

Collaboration is a multidimensional process involving how team members interact (Bedwell et al., 2009; Hackman, 1987; Ilies & Judge, 2005). Specifically, collaboration is the interplay of situation-appropriate uses of teamwork communication (i.e., rich bidirectional information sharing on tasks and good feedback), synchronicity (i.e., being on time with one’s tasks and working in time with one another), and coordination (i.e., expressing and anticipating “who” does “what”) (Chiocchio, Grenier, O’Neill, Savaria, & Willms, in press).

Notably, collaboration and its components predict team performance (Kozlowski & Bell, 2003; Lépine et al., 2008). For example, experiencing good feedback (i.e., high quality, positive and task- or maintenance-oriented as required) lead to good team decisions (Bonito, Wittenbaum, & Hirokawa, 2009). In addition, teams that are good at reflecting constructively on their internal processes also manage them well (Millward, Banks, & Riga, 2010). Hence, team members’ knowledge of how their team’s collaborative processes unfold in time is important, especially in complex project team environments (Chiocchio, 2007).

Collaboration is determined by, occurs with, or fosters a number of important behaviors and affective states crucial to team performance. Collaboration implies sharing and collective action “oriented toward a common goal in a spirit of harmony and trust” (D’Amour et al., 2005, p. 116) and “is a function of the recursive interaction of knowledge, engagement, results, perceptions of trust, and accumulation of activity over time” (Martínez-Moyano, 2006, p. 83).

In sum, collaborative processes are major contributors to efficient and efficacious interdisciplinary teams in the building industry. Just like in other types of teams involving high interdependence, we generally posit that collaboration will positively affect team performance. However, building industry specialists, project management theorists, and work, industrial, and organizational scholars position collaborative processes as one of many factors at play in team effectiveness. In the next sections, we will expand on two such factors—namely, trust and conflict in teams.

Intrateam Trust and Team Performance
Trust has been studied with regard to interpersonal work relationships, teams, organizations, governance structures, and even societies as a whole (Costa, 2003). Trust can be seen instrumentally (i.e., trust occurs as a function of predictability and expectations regarding others’ behaviors) or in terms of beliefs in others’ competencies. For example, broken promises on the likely availability of design information are an important issue in the construction industry (Rounce, 1998). Fiduciary trust occurs when people are relying on someone with specialized training and knowledge, while lacking the expertise and information to understand their actions. While in such a case others’ competencies are unknown and predictability is low (Tyler, 2003), it is interesting to note that for team members to trust in the team, they must feel that the team is competent enough to accomplish its task (Ilgen et al., 2005). Trust is therefore fundamental to interdisciplinary teams such as in integrated design teams, as no one member possesses the expertise to address all of the design project’s challenges.

Generally, studies on group trust show it is positively related to team performance, especially when the work requires high interdependence between team members (Gully, Incalcaterra, Joshi, & Beaubien, 2002). It is thought that trust affects performance through activation of cooperation (Tyler, 2003).
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or other collaborative processes. By enhancing collaborative processes, trusting teams can better manage the interdependencies between their respective expertise spaces. Costa (2003) argues that trust facilitates coordination among individuals because a high level of trust increases the likelihood that one will cooperate and share information with team members, which in turn is expected to lead to higher performance.

This discussion points to interactive team processes such as collaboration as a key factor relating trust to performance in teams in general. To our knowledge, no prior studies have focused on this relation in integrated design teams. Consequently, we will test the following hypothesis:

**Hypothesis 1:** Collaboration is a positive mediator in the positive relation between trust and performance.

**Task Conflict and Team Performance**

The building industry is far from immune to conflicts, given the adversarial relationships between contractors and design teams and an unwillingness to work with people of divergent views or different design disciplines (Rounce, 1998). Specifically, the design phase is prone to issues with personalities (Arditi & Günaydin, 1998), such as adopting a political or protectionism stance on quality problems and inability to recognize quality failures due to pride (Rounce, 1998). Teams provide an interpersonal context in which conflicts and ways to manage them emerge (Alper, Tjosvold, & Law, 2000). Conflicts start with perceived incompatibilities or discrepant views among the parties involved and evolve into behavioral reactions (Jehn & Bendersky, 2003).

How conflicts come to be and how they affect performance is complex. In terms of determinants, early conflict scholars asserted that conflict follows from a breakdown in cooperation (Pondy, 1967, in Jehn & Bendersky, 2003), suggesting certain forms of social processes are closely linked to conflicts. Others suggest that active intrateam problem solving accentuates the ties between people and reduces the potential for future conflict (De Dreu, Weingart, & Kwon, 2000). In terms of impact, conflict scholars have generally shown that team conflict causes a number of negative outcomes, such as decreased individual satisfaction, reduced creativity and risk taking, and decreased team performance (De Dreu & Weingart, 2003; Jehn & Bendersky, 2003). Tellingly for integrated design teams, conflict and diversity (i.e., cultural, or in terms of background or discipline) are often linked (Jehn, Bezrukova, & Thatcher, 2008). Bettenhausen (1991) concluded that the overall effect of diversity on team performance is negative in part because of difficulties reaching team consensus. This negative effect still resonates in more recent reviews, where it is seen that “member heterogeneity exhibits consistently weak relationships with team performance” (Stewart, 2006, p. 45). However, Stewart found some support for diversity’s positive effect on performance in uncertain and dynamic environments and as a result, he suggested that processes such as coordination greatly impact teams performing complex and creative tasks.

One of the most studied forms of conflict is task conflict. Task conflicts are disagreements about specific activities teammates must perform (Jehn, 1995) to advance the project: they are problems with “what to do.” Despite a prevailing notion suggesting task conflicts benefit teams, De Dreu and Weingart (2003) convincingly showed that such disagreements impede team performance, and “the emerging consensus is that task conflict is generally unhelpful for teams” (Ilgen et al., 2005, p. 529). Consequently, “how conflict is managed within teams is critical in determining its effect on performance” (Williams & Allen, 2008, p. 128; italics in the original). Furthermore, conflict management is considered the central task of autonomous and self-managed teams (Alper et al., 2000) such as integrated design teams.

Task conflicts can be discussed effectively or ineffectively (Tjosvold, 2008). When individuals are highly concerned with themselves and concerned with others in the team, they tend to choose problem-solving strategies of conflict resolution (Olekals, Putnam, Weingart, & Metcalf, 2008). These authors added that problem solving is driven by a willingness to collaborate. We believe that collaboration, with its emphasis on rich bidirectional communication, synchronicity, and coordination of activities, represents an effective strategy that will help teams discuss task conflicts effectively. To our knowledge, no prior studies have examined such a relation in integrated design teams. Consequently, we will test the following hypothesis:

**Hypothesis 2:** Collaboration is a positive mediator in the negative relation between task conflict and performance.

**Temporal Dynamics of Teams**

Time is important in teams (McGrath, 1991). We know, for example, that team members’ perceptions of goal interdependence affect how they act with one another, and these interactions are “likely to be sustained for the duration of the contextual configuration” (Young, 2003, p. 83)—that is, as long as they are on the team. But team dynamics are intricate and involve much more than perceptions of goal interdependence. Both the Theory of Compilation (Kozlowski et al., 1999) and the Action–Transition model (Marks et al., 2001) postulate points in the development of teams where they become more or less effective. Unfortunately, these theories do not pinpoint when these shifts should occur. Interestingly, because integrated design teams work in a project environment, it is possible to overlay the development of the team...
onto the progression of the project. Here, milestones are crucial elements. Milestones are external events that signal phase changes and help determine if the project is on time, within budget, and on specification (Project Management Institute, 2008).

Our hypotheses assume that intrateam trust and task conflict are related to team performance, but we take it further and postulate that collaboration is the mediator in these relations. Given the state of knowledge regarding issues of time in team development theory and research, we feel it is not possible to clearly predict when and in which direction intrateam trust, task conflict, and collaborative processes will affect team performance. However, given the importance of time in teams in general (McGrath, 1991) and the significance of dynamic processes in integrated design teams in particular (Pektas & Pultar, 2006), we will investigate the following exploratory research questions:

Question 1: Do intrateam trust and task conflict impact individuals’ perception of team performance similarly across phases of the design process?

Question 2: Does collaboration play the same mediating role across phases of the design process?

Method

Participants and Procedure

The sample consisted of 38 participants, eight (21%) of whom were women. The average age was 25.9 years ($SD = 0.82$). Major professions required for designing a green building were represented: 13 (34.2%) architects, 4 (10.5%) civil engineers, 10 (26.3%) construction engineers, 10 (26.3%) mechanical engineers, and 1 structural engineer (2.6%). Participants were asked to take part in an integrated design project team competition. Participants were graduate students from design schools, architectural departments, and engineering schools from two universities (ÉTS-Montreal: Department of Building and Department of Mechanical Engineering; McGill University: School of Architecture). They formed five interdisciplinary teams; each team consisted of two or three architects, one or two mechanical engineers, one or two quantity surveyors, and one structural engineer. Over the course of six weeks, participants had to work collaboratively over three weekends to design and present the concept of a green building intended to house university students, offices, and other facilities. This was a real project with natural constraints (e.g., time, budget) and a concrete payoff: teams were informed that the winning concept would be presented to the ÉTS board of administrators and that the team could be invited to participate in a design charrette with the project architect. At the onset, teams were informed of the design specifications and received a 45-minute introductory presentation on integrated design. They also benefited from workshops on modeling and simulation software. Once formed, teams self-organized their work. Organizers were on hand to respond to questions and offer guidance when requested. At the end of each weekend, participants responded to a questionnaire (to be described shortly) and submitted their projects in the form of a 10-minute PowerPoint presentation. All working files, mock-ups, and drawings were also gathered. Two days later, the teams presented their project in a public forum. A panel of experts (the architect responsible for the project, a specialist in sustainable construction, the director of ÉTS Facilities Management, and a representative of the student association) examined the material and provided feedback before the next weekend. In the week following the last weekend, teams presented their concept in front of an audience and a panel of judges. Both the audience and the judges marked each concept on criteria such as overall architectural quality of the project; design strategy; integration of the building in its cultural, environmental, and social contexts; structure and envelope; sustainability; materials; mechanical systems; and compliance with the budget. All participants signed a consent form and agreed to take part in this study.

Measures

Because team members have the best understanding of how well their team performs tasks in relation to their objectives (Costa, 2003), we used several validated, short, self-reported questionnaires grouped into one battery. Intrateam trust was measured using a five-item questionnaire taken from Simons and Peterson (2000). Answers to questions such as “We absolutely respect each other’s competence” were collected on a five-point Likert scale (i.e., $1 = strongly disagree, 5 = strongly agree). These authors reported internal consistency indices of $\alpha = 0.89$. Task conflict was measured using Jehn and Mannix’s (2001) three-item questionnaire adapted to reflect occurrences of key behaviors (e.g., “How frequently does your team experience disagreements about who does what?”). Participants responded using the following scale: $1 = never or almost never; 2 = occasionally; 3 = relatively often; 4 = often; 5 = very often. Jehn and Mannix reported $\alpha = 0.94$. Collaboration was measured using the Collaborative Work Questionnaire, a 14-item questionnaire measuring communication (e.g., “My teammates and I share knowledge that promotes work progress”), synchronicity (e.g., “My teammates and I carry out our tasks at the appropriate moment”), explicit coordination (e.g., “My teammates and I discuss work deadlines with each other”), and implicit coordination (e.g., “My teammates and I can foresee each other’s needs without having to express them”) (Chiocchio et al., in press). The authors reported internal consistency estimates drawn from two independent samples in excess of $\alpha = 0.90$. Team performance...
was measured using a questionnaire developed by Griffin, Neal, and Parker (2007) designed to tap into three dimensions of team effectiveness: proficiency (e.g., “I provided help to coworkers when asked or needed”), adaptivity (e.g., “I responded constructively to changes in the way our team works”), and proactivity (e.g., “I developed new and improved methods to help the team perform better”). Various validation procedures yielded α coefficients above 0.72.

**Statistical Treatment and Software**
Data was checked and cleaned according to Tabachnick and Fidell’s (2007) recommendations. That is, no univariate or multivariate outliers were found, and only a few (i.e., less than 2.6%) missing data points were excluded pairwise. Data was then analyzed using specialized statistical software (SPSS, 2008), as well as special routines designed to test indirect mediating effects (Preacher & Hayes, 2004).

**Results**
Table 1 shows α coefficients for the questionnaires, means, and standard deviations, as well as the correlation matrix for all the variables under study. As expected, these simple relations show positive ties between trust, collaboration, and perceptions of performance. As expected, relations with task conflict are negative. Results for Hypothesis 1 (regarding trust) appear in Table 2. Table 3 shows the evidence for Hypothesis 2 (regarding conflict). Both tables are constructed the same way and display complex relations between variables at and between each time of measurement. Information on the diagonals that intersect at time 1, time 2, and time 3 show measurements taken at the end of the first, second, and third weekends, respectively. Off-diagonal elements show intertime relations with collaboration and either trust or conflict taken at times 1 or 2 and their impact on performance measured at times 2 or 3.

Arrows represent relations between the independent variable (i.e., X, either trust or conflict) and performance (i.e., Y, the dependent variable) as well as with collaboration (i.e., M, the mediating variable). Numbers next to arrows represent the magnitude of relations. The number appearing inside the arrows expresses whether or not collaboration actually mediates the relation between trust or conflict and performance.

Examining on-diagonal results at time 1 in Table 2, we can see that trust’s impact on performance is moderate and statistically significant (r = 0.36, p < 0.05). In parallel, the relation between trust and collaboration is positive and moderate (r = 0.38, p < 0.001), and the relation between collaboration and performance after controlling for trust’s effect is strong.

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Table 1: Zero-order Pearson correlation (r) of all variables under study across times.
Table 2: Mediator effect of collaboration (M) on the relation between intrateam trust (X) and team performance (Y) within and across time.

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*p < 0.05. **p < 0.01. ***p < 0.001.

Table 3: Mediator effect of collaboration (M) on the relation between task conflict (X) and team performance (Y) within and across time.

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<td>-0.11 (-0.58***)</td>
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*p < 0.05. **p < 0.01. ***p < 0.001.
(r = 0.67, p < 0.01). More importantly, the relation between trust and performance disappears completely once the combined effects of the relations involving collaboration are taken into account (r = 0.11, ns). The Sobel test of indirect effects (see Preacher & Hayes, 2004) confirms this phenomenon (S = 0.25, p < 0.05). These results mean that at time 1, trust asserts its positive influence on performance through positive collaborative processes—as such, collaboration is a full mediator of the trust–performance relation. Results are similar for time 2 (S = 0.25, p < 0.01) and time 3 (S = 0.36, p < 0.01), as seen on the diagonal. Taken together, these results suggest collaboration fully mediates the trust–performance relation and thus shows strong support for Hypothesis 1.

Turning to Table 3 and the results regarding conflict, the elements on the diagonal support Hypothesis 2. That is, collaboration fully mediates the relation between conflict and performance at time 1 (S = −0.39, p < 0.05), time 2 (S = −0.32, p < 0.01), and time 3 (S = −0.47, p < 0.001). Particularly for times 1 and 3, large and statistically significant direct effects (i.e., r = −0.55, p < 0.01, and r = −0.58, p < 0.001, respectively) disappear once collaboration is taken into account (i.e., r = −0.17, ns, and r = −0.11, ns, respectively). A similar trend is visible at time 2 but does not reach statistical significance.

Examining the off-diagonal patterns in Tables 2 and 3 answers our research questions. For trust, off-diagonal patterns show intertime relations between trust and collaboration on the one hand and performance at later times. Full mediation occurs when considering trust and collaboration at time 1’s effect on performance at time 2 (S = 0.22, p < 0.05) and on performance at time 3 (S = 0.43, p < 0.01). The same trend is evident upon examining trust and collaboration at time 2’s effect on performance at time 3. However, even if the moderate direct effect (r = 0.29, p < 0.05) disappears once collaboration’s effect is taken out (r = 0.08, ns), the indirect effect fails to reach conventional statistical significance (S = 0.21, ns). It is worth underscoring that the relation between trust at time 1 and performance at time 3 drops from moderate (r = 0.48, p < 0.01) to essentially nothing (r = 0.06, ns) once collaboration at time 1 is taken into account.

For task conflict, off-diagonal tests of indirect effects show that collaboration is a full mediator. Specifically, collaboration at time 1 fully mediates the relation between conflict at time 1 and performance at time 2 (S = −0.36, p < 0.05) and performance at time 3 (S = −0.60, p < 0.01). In addition, collaboration at time 2 fully mediates the relation between conflict at time 2 and performance at time 3 (S = −0.25, p < 0.05). In these three cases, although two out of three direct effects do not reach conventional levels for statistical significance, all correlations reduce substantially once collaboration is taken into account. Notably, the relation between conflict at time 1 and performance at time 3 goes from very large (r = −0.89, p < 0.001) to a magnitude not statistically distinguishable from 0 (r = −0.29, ns) once collaboration at time 1 is taken into account.

Discussion

Summary of Major Contributions

Based on current theories of team development, we tested stringent hypotheses regarding the role that emergent states and team processes play in integrated design teams’ effectiveness as they develop during three intense two-day work sessions occurring over a six-week project. To our knowledge, no other study has ventured to investigate trust, task conflict, collaborative processes, and perceptions of team performance in integrated design project teams. We are the first to have mapped the role collaboration plays— and the extent to which it plays—in the positive trust–performance relation or in the negative task conflict–performance relation. Finally, only a handful of scholars have examined such relationships while considering the progression of teams in time. These issues are of considerable theoretical and practical importance.

On a conceptual level, our results show moderate to strong support for a within-time full mediation effect of collaboration between trust and performance and between conflict and performance. In addition, results show moderate to strong support for an intertime full mediation effect of collaboration. Taken together, we conclude that it is not possible to dismiss the importance of how individuals’ perceptions of collaborative processes impact the development and performance of integrated design teams.

In practical terms, if trust and task conflict have a direct and exclusive relation to team performance, collaborative efforts are in vain and are costly processes that teams should do without. However, it turns out that trust and task conflict require collaboration to impact team performance. Hence, integrated design teams must learn to collaborate more effectively in order to benefit from trust or manage task conflict. In the context of this research, improved collaboration implies better bidirectional communication and feedback, heightened synchronicity, and more explicit task coordination as well as anticipatory coordination.

Theoretical and Conceptual Implications

Our results point to specific theoretical underpinnings as well as future conceptual work on collaboration. Our results extend the current knowledge on collaboration, trust, and conflict. We already knew that perceptions of trust and conflict influenced outcomes such as performance. However, our study shows that, although the negative effect of task conflict early in the project affects how people feel about performance at the end of the project, the team
members’ view of how their team collaborates fully mediates this negative effect. Hence, given that team conflict is inevitable (Jehn, 1995) and is “something people do and must act upon” (Tjosvold, 2008, p. 449), our results cast collaborative processes as to precisely what can be done in the specific case of integrated design teams. Similarly, how our participants felt regarding their teams’ collaborative behaviors explained how trust operates on performance over time.

Most scholars note the importance of assessing how teams develop over time but, in the same breath, note the difficulties of conducting studies that can shed light on such processes. We tackled this challenge and found that, generally, relations between intrateam trust and collaboration grow stronger from phase to phase. Furthermore, the trust–performance relation grows over time, as does the collaboration–performance relation. More importantly, the effect of collaboration on the relation between trust and performance also grows from phase to phase. We found a similar pattern for task conflict. The conflict–performance relation grows somewhat over time. In addition, the effect of collaboration on the relation between task conflict and individuals’ views on team performance grew over the course of the design project. These are major contributions to team research and to the literature on integrated design team effectiveness, which we hope other scholars will want to replicate.

Because our study examined the development of integrated design teams over the course of a project, our results suggest additional theoretical endeavors scholars should pursue. One is the gap between project management theories and team development theories. On the one hand, project management scholars and practitioners—largely unaware of current theories of team development—use milestones to assess the technical progress of their project but are left without means to assess or control their development. On the other hand, work, industrial, and organizational scholars—who, for the most part, are unaware of how milestones mark the evolution of a project—postulate transition points in teams’ life cycles but do not know when such transitions occur (Kozlowski et al., 1999).

Specifically, both the Theory of Compilation (Kozlowski et al., 1999) and the Action–Transition model (Marks et al., 2001) suggest shifts in team dynamics where teams become more—or less—effective. Our results suggest that project milestones may have served as markers of the development of trust, conflict, and collaboration, and as opportunities for team members to reflect on their team’s effectiveness. The larger question that should be investigated is the extent to which the technical progression of projects, as measured and driven by milestones, can be purposefully overlaid onto transition points postulated by team development theories. Doing so would mean that integrated design teams could be asked to meet various project milestones at various points in time not only to make sure the design project is on time, on budget, and on specification, but also to help the team transition to increased levels of collaboration.

Another theoretical endeavor that should be pursued revolves around the context in which conflict occurs. Deutsch (2003) explained that conflict can occur in a competitive context or in a cooperative context. Cooperative contexts are those in which parties help each other with tasks when the outcome is mutually beneficial (Evans, 2003). Cooperative contexts are more likely to elicit trustworthy information, effective communication, and high coordination, whereas mistrust is pervasive in competitive contexts (Deutsch, 2003). Interestingly, our study took place during an interteam competition where each integrated design team member had to demonstrate intrateam collaboration. The moderate to large relations we uncovered may have been the result of this mixed context. Even if some scholars show that an interteam competition context can be performance-conducive (e.g., sales teams) (Millward et al., 2010), more work is necessary to determine if interteam competition affects intrateam processes such as collaboration. One way to find out is to compare competitive integrated design projects to noncompetitive ones. If interteam competition is the main driver of intrateam collaborative processes, integrated design teams should pursue design competitions.

**Practical Implications**

Our study shows that collaboration boosts the positive effect of trust and dampens the negative effect of task conflict, offering the opportunity to substantially improve performance. This result has a number of practical implications. On the one hand, because architects and engineers learn their trade from inside impermeable knowledge universes, they are not exposed to boundary-spanning activities and interdisciplinary collaborative processes. This does not prepare them well for the future work environment, which is geared toward cross-functional and interdisciplinary teamwork (Kozlowski & Bell, 2003). Universities, design schools, and the like should provide rich interdisciplinary project-based experiences that offer opportunities for students to learn and receive feedback on collaboration skills (Chowdhury, Endres, & Lanis, 2002; Dunn, McCarthy, Baker, Halonen, & Hill IV, 2007). Some suggest that only yearlong multidisciplinary capstone projects would help designers build up their skills (Gruenthier et al., 2009). Our study shows that short and intense projects provide rich experiences when it comes to trust, conflict, and collaboration.

Design and other building industry specialists assert that integrated design project teams composed of seasoned professionals experience difficulties abandoning typical command and
control ways (Arditi & Günyaydin, 1998; Rounce, 1998). Even if our study shows that fostering trust and avoiding task conflicts would be a step in the right direction, a better approach would be to foster collaborative skills using team-building strategies. Team building is “a class of formal and informal team-level interventions that focus on improving social relations and clarifying roles, as well as solving task and interpersonal problems that affect team functioning” (Klein et al., 2009, p. 183). Klein and colleagues found that team building is especially effective in the case of teams facing affective and processes-related issues as well as having to improve goal setting and clarify roles.

**Limitations and Future Research**

No study is above limitations, and two are notable here. First, our sample consisted of graduate students from different universities who voluntarily engaged in a competition. Our participants had limited professional experience and no prior history of working with the other participants they were paired with. Consequently, caution should be exercised before generalizing our results to teams of experienced professionals. Second, we were only able to survey 38 participants grouped into 5 teams. In addition to limiting our grasp of team-level phenomena, the small number of individuals limited the extent to which our statistical procedures were able to detect statistically significant effects.

**Concluding Remarks**

We began this article with a quote on the challenges preventing paradigmatic shifts. We invested serious efforts to push through and orchestrate two such shifts. First, a focus on sustainable development and changes in the design process from linear and fragmented to integrated and iterative requires a major transformation of how work is organized and how team members interact. Integrated design team members must overcome traditional power structures and mindsets. They must undergo changes in attitude and learn how to solve old problems in new ways as well as solve new problems. Even if all teams “must be nurtured, supported, and developed” (Klein et al., 2009, p. 182), integrated design project teams are particularly in need of learning to trust, to manage task conflicts, and to collaborate effectively.

The second paradigmatic shift is in our response to challenges faced by sustainable development and integrated design teams. We took footing on theoretical foundations from the field of work, industrial, and organizational psychology. For design and construction scholars and practitioners, this shift requires a major adjustment in thinking and the acquisition and application of new knowledge from a relatively unknown field. We believe that this innovative and strong theoretical stance represents a major contribution to the field of design in general and to teamwork in design teams in particular. We hope our study will encourage other scholars and practitioners from both fields to engage—as we did—in interdisciplinary collaborations.

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