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TRUST IN CROSS-FUNCTIONAL, GLOBAL TEAMS: DEVELOPING AND VALIDATING A MODEL OF INTER-PERSONAL TRUST IN CROSS-FUNCTIONAL, GLOBAL TEAMS

A DISSERTATION SUBMITTED TO
THE DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
AND THE COMMITTEE ON GRADUATE STUDIES
OF STANFORD UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

Roxanne Zolin

May 2002

I certify that I have read this dissertation and that, in my opinion, it is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

Dr. Raymond E. Levitt

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Dr. Pamela J. Hinds

Approved for the University Committee on Graduate Studies:

Abstract

Globalization, increased competition and the availability of Internet technology are creating distributed teams to achieve goals that require multiple disciplines, such as engineering design, and new product development. Cooperation and problem solving in these teams require more trust than in traditional homogeneous, collocated teams, but geographic distribution and cross-functional team composition makes trust difficult to achieve.

This dissertation investigates the interactions between the many factors that influence inter-personal trust in cross-functional, global teams. My aim is to develop a deeper understanding of how trust develops, in order to build, repair and maintain trust in distributed teams containing multiple disciplines.

Until recently, there was little agreement about the nature of trust and how it develops. The definition of trust that I use is *Trust is the willingness to accept a risk based upon the expectation that another party will perform, regardless of your ability to check*. Theories propose that inter-personal trust is based upon shared social categories, roles, third party information, social rules, history of the relationship and the trustor's disposition. Although most of these theories have been tested individually, no model combining these theories has yet been tested.

To tackle this problem, I integrated the theories of trust into a model that identifies the major variables that predict inter-personal trust. In the first year, I observed teams at work in a Problem-based learning (PBL) educational environment and developed ways to measure the variables that predict trust in the model. Over the next

two years, I surveyed hundreds of global, cross-functional pairs of coworkers and used the information gained to refine, test and validate the model of inter-personal trust.

I found that many of the expected model relationships were confirmed. Perceived trustworthiness and risk predicted trust. My model extensions were also confirmed. Reward predicted trust and perceived performance predicted perceived trustworthiness. Contrary to my expectations, I also found that perceived performance mediates the relationship between perceived trustworthiness and trust. Particularly in distributed dyads, it appears that participants relied on their perceptions of their team members to evaluate the extent to which these team members met expectations. I also found that distributed team members changed their level of trust less than those who were collocated.

I also consider the applicability of PBL environments for work-related studies. I propose that the more realistic the PBL work context and workgroup composition, the better the PBL data source as a proxy for an industry sample. PBL course design can also contribute to the research design by using random assignment to teams, annual continuity, and research techniques appropriate to the sample size.

Acknowledgements

The last four and a half years at Stanford have been the second greatest experience of my life.

I choose Stanford because I wanted to add the human element to organizational simulations and Professor Ray Levitt's Virtual Design Team (VDT) simulation looked like the perfect simulation and Ray looked like the perfect advisor. As it turned out, my intuition was correct about both VDT and Ray. Unfortunately, when I choose to work on trust, I could not find any validated model of trust to use as my point of departure. Luckily, Professor Renate Fruchter from the Center for Integrated Facilitates Engineering (CIFE) expressed an interest in my work and offered her Project-Based Learning environment as a test bed to develop a theory and model of trust. I offer my deepest gratitude to the faculty, mentors and students in Renate's CEE222 classes for putting up with my observations, questionnaires and interviews from 1999 to 2001. With Ray and Renate's help I started building and testing the model, but I needed more help with the literature and methodology. Again providence shone upon my project when Professor Pam Hinds of the Work Technology and Organizations (WTO) group joined my research team. I would like to thank Ray, Renate and Pam for providing the just the right combination of advice, focus, feedback and friendship.

One of the most useful things I have learned at Stanford is embodied in the saying "Knowledge is socially constructed." This helped me to appreciate the value of the wonderful interactions I experienced during this journey. All Stanford faculty contributed above and beyond the call of duty, but some whom I shall always remember with gratitude, include Dr. Rodney Kramer from the Graduate School of Business, Dr. Cecilia

Ridgeway and Dr. Karen Cook from the Sociology Department, Dr. John Kunz from CIFE, Dr. Bob Tatum for serving on my exam committee, Dr. Jim March from every department and Dr. Dick Scott, who is the only person on this planet allowed to call me "Roxy". I have also been blessed to be here during the visits of Dr. Borge Obel from Odense University, Dr. Kathleen Carley from Carnegie Mellon University, Dr. Russell Hardin from NYC and Dr. Jan Smedslund from the University of Oslo. Any thanks to the great professors at Queensland Institute of Technology, Terry Euler and Su Mon Wong, whose encouragement got my career started.

Stanford excels because its great staff support its great faculty. My thanks and sympathies to our Program Co-ordinator, Diantha Stensrud, "the glue that holds this place together." Thanks to Diantha, Teddie Guenzer at CIFE, Paula Wright in WTO, Brenda Sampson and Marie Ouchi-Jacobs I was able to find things when I needed them, get paid on time and leap over red tape in a single bound.

One of the greatest benefits of a Stanford education is the practical advice provided by your student cohort. I was initiated into the mysteries and realities of the PhD program by my great friend, Dr. Jolin Salazar-Kish, who graduated from the Construction Engineering Management (CEM) to become the "real estate mogul of New Hampshire." Other students in our research group, who also contributed to the construction of my little piece of knowledge and enjoyment of the process, include Dr. Walid Nasarallah, Dr. Doug Fridsma, Sam Miller, Monique Lambert, Ray Buttener, Carol Cheng, Mike Murray, and Ashwin Mahalingam. Special thanks to my CIFE office mates, Chao Yunn Chi, and Peter Demian, who understand the value of sharing food in development of social capital. Students from other groups, schools and departments also

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Many thanks to all the folks I served with on the Graduate Housing Advisory Committee, for providing me with an venue to exercise and test my theories of trust during three very difficult years of housing shortages.

Thanks to my father, Gilbert Van Blarcom, for providing the means to get started on this journey and to "me Mum", Vida Rideout for teaching me to love reading and books. Thanks to the rest of my family in Australia, Canada and the USA for their e-mails that made the sojourn in the wilds of California not quite so lonely as it might have been. Thanks to my son, Jason, for making the trip from Australia to see my Oral Defense. Thanks to my adopted American sister, Rhonda Wilcox, for telling me when I am being really stupid.

And to my dearest, darling husband Mario Zolin, thank you for giving me the greatest experience of my life and preparing me for the second greatest. I dedicate this work to you.

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Chapter 1.

Introduction

A global Architecture Engineering and Construction (AEC) firm with offices worldwide wins a competition to build a new hotel in Singapore at a cost of over $100 million. The Architect is assigned from the London office to team up with the Structural Engineer from the firm's design group in the San Francisco office, and must contract with a General contractor and sub contractors in Singapore. In order to save time and money and better manage and track information, the team will use the best information and collaboration technologies available – but there is no existing formalized process to help them build trust. The stakes are high; the hotel must meet performance requirements; and it must be delivered on time. Competition to obtain this project was fierce and the budget has very little slack. But the biggest challenge may not be producing creativity or ensuring safety or meeting deadlines or managing cost. Each of the team members must face and overcome personal barriers to cooperation.

They must learn *how* to trust one another:

- Not the trust of familiarity. These people have never met each other before.
- Not the trust of similarity. These people work in different disciplines and come from different cultures.
- Not the trust of future necessity. These people may never work together again.
- Not the trust of organizational security. These people may not work for the same organization nor do they share the same organizational culture.

Trust is the willingness to accept a risk based upon the expectation that another party will perform, regardless of your ability to check (Mayer, Davis and Schoorman, 1995)

Cross-functional, global teams, sometimes called "virtual teams" often start fast; and they perform non-routine work with heterogeneous membership within weak organizational structures (Wong & Burton, 1999). Members of such teams need to learn how to trust in a fast start, temporary, multidisciplinary, distributed team. To trust when there is no previous relationship or history to go on; when they don't see things from the same perspective; when they have different goals; when they have no commitment to the relationship in the future; and when there is no authority to protect them if the team member fails to perform.

The challenge of learning this kind of trust is becoming more and more common in today's workplace, with faster project starts, greater professional specialization, and now, with the help of communication technologies such as the Internet, greater geographical dispersion of teams. Nowhere is this challenge more obvious than in the construction industry where global architecture, engineering and construction (AEC) teams with numerous players are standard operating practice.

Possibly recognizing that unwarranted mistrust is an undetectable mistake—a form of avoidance learning—many popular management writers advocate the adoption of more trusting relationships. This could lead to disaster if team members are not trustworthy. This research identifies two failures of trust; unwarranted trust and unwarranted mistrust. The issue is to learn how to trust when team members are trustworthy, and not to trust when your team members are untrustworthy.

How can organizations rise to the challenge and bridge the widening chasm between the increasing need for trust and the increasing difficulty to trust, in cross-functional, distributed workgroups?

The Importance of Trust in Cross-functional, Global Teams

Trust is a frequently mentioned topic in the construction industry, the Internet community, the business community, and the political arena. There is increasing recognition of trust as a social good or social capital that is fundamental to human interaction and cooperation (Putnam, 1995), (Paxton, 1999), (Child & Faulkner, 1998), (Fukuyama, 1995).

Some of the reported benefits of trust are better productivity and quality performance (Hagen and Choe, 1998). These benefits may be attributable to removing the costs of lack of trust, which tend to be non-productive behaviors such as non-cooperation, excessive checking and protective controls.

In the traditional design process, the Architect designs the exterior and floor plan of the building and "throws it over the wall" to the Structural Engineer. The Structural Engineer designs the structural support system of the building and "throws it over the wall" to the Construction Manager. The Construction Manager plans the construction sequence and prepares the budget and time schedule.

The problem with this approach is that if the structural Engineer identifies a structural problem, or the mechanical engineer identifies a problem such as a lack of space for risers, the plans must go back to the Architect to be corrected. This is likely to be a larger correction than if the Engineer was able to identify the problem

contemporaneously with the Architect's original design process. The same applies with the Construction Manager who may find that the building is difficult to construct, costs too much, or will take too long to build.

The Design/Build construction contracting process allocates responsibility for design and construction functions to one business entity— frequently a joint venture corporation created for a single project. By working together as a team to design, analyze and plan a structure, problems can be identified sooner when they are less expensive to fix. Moving from a traditional design process to the design/build process implies moving from a sequential to reciprocal interdependence (Thompson, 1967).

With the introduction of the Internet, design teams in the construction industry, which always tended to be distributed across companies and space, now fit Wong and Burton's (1999) description of the virtual team. Virtual Teams (Wong and Burton, 1999) have virtual context, virtual composition and virtual structure. *Virtual context* means that the team members often have no prior history of working together; the tasks tend to be non-routine and completed under time pressure; and the members of the team are not physically collocated. Thus team members are deprived of some types of information normally used to build trust. *Virtual composition* refers to the heterogeneous character of the team membership represented by different cultures and different disciplines. Thus team members are less likely to find cultural or value similarities upon which to build trust and are more likely to have misunderstandings due to differences in basic assumptions. *Virtual structure* is represented by the weak lateral relationships that are characteristic of such teams. Thus the leadership, power and control provided by traditional hierarchy structures are not available. In summary, the context and

composition of virtual teams discourage the development of trusting relationships whereas the virtual structure depends upon it. This suggests that the development of trust is critical to both performance and worker satisfaction in a distributed workgroup.

Success in the construction industry depends upon the exercise of trust among project team members. This is due to the virtual nature of design teams in the construction industry, the interdependent nature of the tasks performed by fragmented project organizations and the risks that interdependence entails (Thompson, 1967). Trust is required to facilitate cooperation between the specialized and consequently fragmented mosaic of disciplines required to build even a simple structure. Complicated and precise scheduling dependencies require trust for delivery on time. The fast start of project teams requires *swift trust* (Meyerson, Weick & Kramer, 1996). The one-time nature of most AEC project teams removes the "shadow of the future" which motivates cooperation in longer-term relationships (Axelrod, 1984).

Whereas the need for trust is high and demands upon trust are great, so too is the cost of failure of trust. Such costs include lower productivity, less creativity, more mistakes, lost opportunity, increased vigilance, increased surveillance, and time spent waiting for paperwork to go through channels to avoid risk. In addition, worry drains emotions and diverts attention from the job at hand (Kramer, 1999).

Business writers agree that trust is central to teamwork, leadership and organizational culture (Fairholm, 1994) (Nicholas, 1993), (Ryan, 1999). The business community recognizes the importance of trust implicitly as well as explicitly. The implicit recognition of trust is evidenced in writings about organizational culture, leadership and team building. Management literature describes the operation of trust in

the business environment, measures trust using surveys that are based upon untested factors (Duarte & Snyder, 1999) and prescribes formulas based upon anecdotal material (Shaw, 1997). Rarely does it progress beyond the anecdotal level due to the lack of any theory or model to provide a level of analysis.

The current approach promoted by many team-building exercises merely promotes increasing trust. This simplistic view can lead to a failure in performance if the trustee is not trustworthy. Trustworthiness is the extent to which the trusted person is ready, willing and able to meet the performance requirements. Trusting an untrustworthy person could lead to failure to perform and is likely to decrease trust in future.

These problems are exaggerated by the lack of any accurate language of trust. In the English language the word trust is used to mean many different things from the attitudes and feelings associated with trust, to the behavior evidenced by acting on trust and the perceived trustworthiness of the other party. This confusion is compounded when different cultures try to enter a dialogue about trust because each culture has different expectations upon which they base their trust and different ways of evaluating another's trustworthiness.

Research Question

This research attempts to answer the following research question:

Of the many variables that have been proposed to affect trust, which factors, when examined together, are the most important predictors of trust in cross-functional distributed teams?

Point of Departure

A clear, unambiguous definition of trust is especially important when trying to factor trust into a computational or mathematical model. (Lerch, Prietula & Kulik, 1997), (Muir, 1994), (Urban, Sultan and Qualls, 1999), (Marsh, 1994).

The academic research community agrees that trust is essential in relationships (Seligman, 1997), (Grovier, 1997), (Shapiro, 1987), (Hardin, 2000). Despite this fact, there is no agreed upon definition of trust (Hardin, 2000). Researchers say that trust is a "**calculation** of the likelihood of future cooperation" (Williamson, 1993), "an **orientation** toward society and toward others" (Kramer & Tyler, 1996), "an **incorporation** of risk into the decision of whether or not to engage in the action" (Coleman, 1990), "the **expectation** that specific others will reciprocate trusting behavior" (Kramer & Tyler, 1996), "a **state** involving confident positive expectations about another's motive" (Boon and Holmes, 1991), "the **confidence** that one will find what is desired from another" (Deutsch, 1973), "an actor's **willingness** to arrange and repose his or her activities on [an] other" (Scanzoni, 1979), "the **degree of confidence** you feel when you think about a relationship" (Rempel and Holmes, 1986), "a confident **belief** in the integrity and reliability of the other person" (Zimbardo, 1970), "a more or less **consciously chosen policy** for handling the freedom of other human agents or agencies" (John Dunn, cited by Hardin, 1999).

Theorists and researchers have spoken of trust in many different ways. Kramer (1999) has categorized these divergent views of trust into a number of images that range from the social and ethical facets of trust to the strategic and calculative dimensions.

The view of trust as a psychological state focuses on the cognitive processes, and orientations associated with trust (Kramer, 1999). The mental states that are associated with trust include the perception of risk, an attitude of expectance and various affective and motivational states. Trust involves uncertainty and risk taking based on expectations of another person (Meyerson, Weick & Kramer, 1996).

In contrast, trust is also conceptualized in terms of choice behavior (Kramer, 1999). Writers taking this view, point to the conscious calculation of risk versus benefits and the importance of information in that process.

Finally, the rational choice models of trust assume the individual consistently makes rational choices about trust to maximize achievement of goals. Rational choice models contain two central elements (Hardin, 1992): the knowledge that enables a person to trust another and the motivations of the person being trusted. These models have been criticized for lacking the social and affective aspect of trust (Kramer, 1999).

In this research I allow for the understanding that trust operates through both conscious choice behavior and unconscious affective influences.

Mayer and colleagues (Mayer, Davis and Schoorman 1995 p. 712, see also Rousseau, Sitkin, Burt and Camerer, 1998), define trust as "*willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party.*"

In this research I adopt the Mayer et al definition of trust and use the word trust to refer to an attitude about another person (a noun), e.g. "I have trust for you". I also use

the word trust to refer to holding an attitude of trust toward another person (a verb), e.g. "I trust you". When referring to what Mayer et al call "risk taking in relationship" (1995), I used the term "trust behavior" (a verb) to denote acting upon trust, e.g. I trusted him".

Along with others, I also assume that trust can only exist within a particular situation or action (see Gambetta 1988). As Bigley and Pearce (1998) propose, different influences gain ascendency in the trust decision-making process due to different situational and relationship factors. Bigley and Pearce (1998; 406) have argued, it is not a question of "What is trust?" but rather "What trust and when?" Hardin proposes that "**A** trusts **B** about **X**" (2000), to which I add the situational factors and say "**A** trusts **B** about **X** when **Z**".

Theories of Trust Development

Kramer categorizes theories of trust into six groups depending upon how they explain the conditions that promote trust and influence individuals to trust (Kramer, 1999) (See Table 1.1).

Table 1.1– Categories of trust development theories

Category	Independent variable	Intervening variables	Process
Dispositional trust	Individual's personality		The individual's general predisposition influences trusting or non-trusting behavior.
History-based trust	Outcomes of dyadic interactions	Perceived trustworthiness	Dyadic interactions create information about perceived trustworthiness
Third-party conduits of trust	Rumour and gossip	Perceived trustworthiness	Third parties provide information about the trusted person.
Category-based trust	Shared membership	Perceived trustworthiness	In-group bias and attribution of favorable characteristics to the trusted person.
Role-based trust	Role occupancy	Perceived trustworthiness	Roles provide information about the other's perceived trustworthiness
Rule-based trust	Cultural rules, norms and schema	Risks and Rewards	Cultural rules create situations with risks and rewards for trusting.

Dispositional trust theories attribute trust to the individual's general predisposition toward trusting or non-trusting behavior (Rotter, 1970). Rotter developed a scale of "General Trust" that correlated significantly with his sociometric measure of inter-personal trust among college students. When surveyed, individuals do display different attributes towards trusting others in general. Unfortunately, the nature of the questions used in the survey instruments makes it difficult to determine how an individual will respond in a specific situation. For example, the questions do not specify a specific person or task. (See Table 2.1) Yamagishi and Cook and others have developed Rotter's scale of general trust and identified other salient personality characteristics such as prudence or caution (Yamagishi, 1995). The dispositional theory is that, all things

being equal, the higher the trustor's General Trust score, the more likely the trustor will make a positive trust decision.

History-based trust recognizes that trust develops over time as a function of individual interactions between the trustor and the trustee. Experience with the other party provides information about their trustworthiness and through a process of reciprocity creates obligations and expectations that facilitate or frustrate future trust interactions. The history based trust theories propose that the trustor evaluates the results of a trust decision and changes perceived trustworthiness of the trustee based upon that analysis.

Third-party conduits of trust theories propose that information from other people, such as rumour or gossip, provide information about the trustee that the trustor can use to make a trust decision (Granovetter, 1985, p 490 – 91). I propose that this information is used to develop perceived trustworthiness, which is an antecedent to trust.

Category-based trust theories propose that shared membership in a given category can provide the basis for low-risk impersonal trust and that, due to in-group bias, individuals tend to attribute favourable attributes to other in-group members (Brewer, 1996). Observations and affective influences such as the degree of similarity with the trusted person influence the trustor's assessments of the trustee (Kramer & Tyler, 1996, p. 19). For example, if the trusted person is in the same profession, the trustor assumes greater understanding and consequently has higher trust. I propose that category-based trust influences perceived trustworthiness, which influences trust.

Role-based trust theories propose that depersonalised trust is extended to individuals based upon their role occupancy. Roles create expectations about the

individual's performance and intent to fulfil obligations that overcome the need for personal information and relationship. Role-based trust implies that the more clearly roles are understood and shared the easier it is to trust. I propose that information about the role of the trustee influences the perceived trustworthiness held by the trustor.

Rule-based trust acknowledges the cultural basis for trust developed through shared understandings and expectations that are expressed as rules that are both tacit and explicit, formal and informal. Rule based trust is built through socialization processes and maintained through a normative system that operates at unconscious as well as conscious levels. Symbolic behavior creates, communicates, reinforces, or can destroy, this socially constructed and self-reinforcing dynamic. I propose that these cultural rules create a social environment that provides the trustor with the means to determine the potential risks and rewards relating to a specific trust decision.

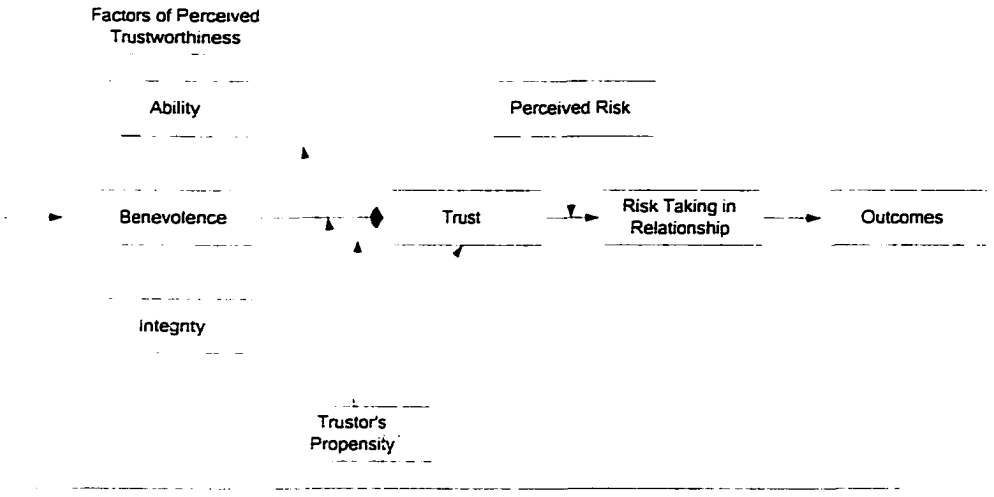
The trust decision-making process is influenced by dispositional, historical, third-party, role based categorical, and rule based factors. The theories of trust as are represented by Kramer's categories do not represent different types of trust but instead represent different factors that influence the trust decision-making process. In different situations one or another of these factors may be more salient than the others. Thus a model of trust needs to incorporate all these factors.

The Mayer, Davis and Schoorman Model

Mayer, Davis and Schoorman (1995) described a model of trust that integrates the theories of trust development (See figure 1.1). In their model the trustor's propensity to trust moderates the effect of ability, benevolence and integrity upon the trust as an

attitude. Perceived risk then moderates the translation of the trust attitude into action, which they call "risk taking in relationship." They then propose that the outcomes of trusting behavior will lead to the updating of dimensions of perceived trustworthiness, ability, benevolence and integrity. The Mayer, Davis and Schoorman Model does not appear to have been validated at the level of inter-personal trust.

Figure 1.1. The Mayer, Davis and Schoorman Model (1995)



Extensions to the current state of knowledge

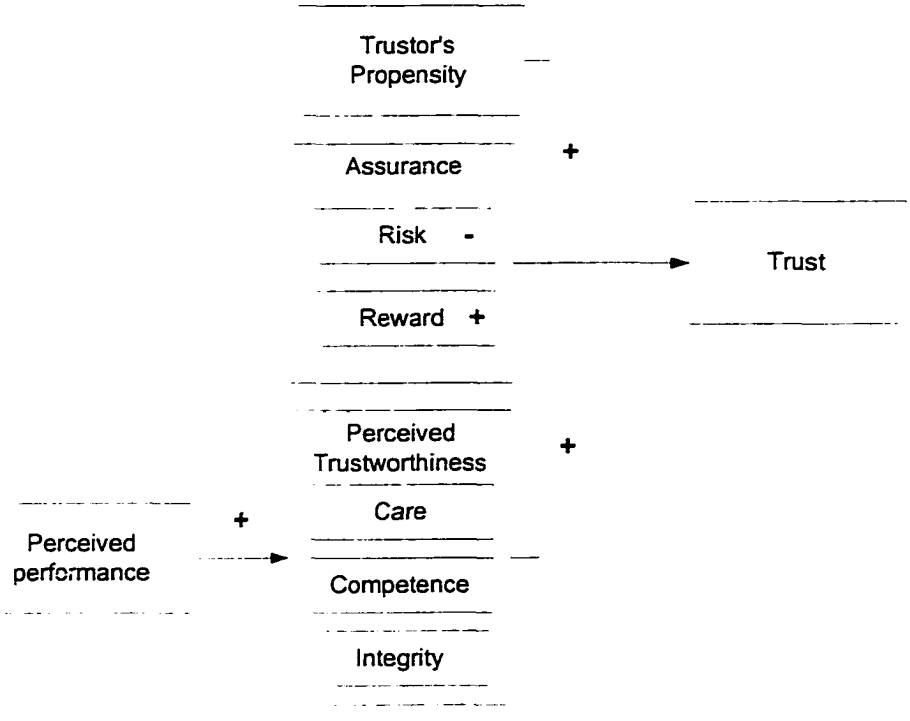
The following section describes how this research extends the Mayer, Davis and Schoorman model of inter-personal trust, validates the model, provides new scales to measure trust and identifies key characteristics of problem-based learning environments as a data source for work-related studies.

Model extensions

Like Mayer, Davis and Schoorman, my model also relies on the trustor's propensity to trust (general trust), the trustor's perception of the trustworthiness of the

trustee, and the trustor's perception of risk. I, however, add several components to the model. First, I argue that perceived performance, like outcomes, is an important behavioral measure on which people rely to determine trustworthiness. Whereas outcomes relates to all results of trust behavior, perceived performance is a specific measure of the extent to which the trustee performed as expected. Second, in addition to considering their own risk, I argue that trustors take into account the potential rewards of making a positive trust decision. My model of trust development is pictured in figure 1.2 and described in detail below.

Figure 1.2: The proposed model of trust development in cross-functional global teams.



Perceived performance

Trust is often represented as a static, binary variable (trust exists or does not exist) but comparative histories give evidence that trust changes over time (Rousseau et al,

1998). One important basis for trust is the history dependent process in which "trust between two interdependent actors thickens or thins as a function of their cumulative interaction" (Kramer 1999, p 575). The process resulting in the change in trust over time begins when an individual's expectations about another party are confirmed or discredited by experience (Kramer, 1999). Thus, once a trustor is given the opportunity to observe a trustee's behavior, the trustor can evaluate the extent to which the trustee has followed through on the commitments made. Our dimension of perceived performance is similar to Bhattacharya, Devinney, and Pittultia's (1998) dynamic model that describes trust in terms of actions, outcomes and consequences. It is also similar to the dimension Mayer et al (1995) refer to as "outcomes." Consistent with these models, I argue that trustors will think their team members are more trustworthy when the trustor perceives that his team members are following through on their commitments. I further argue that perceived performance will be of particular importance on cross-functional, global teams because perceived performance may be more easily and accurately evaluated across discipline, across distance, and across culture than are personality and moral character.

Risk and reward

Consistent with others, I posit that the risk faced by the trustor contributes to his or her willingness to trust. I also propose that the potential for reward is an important situational consideration for the trustor and the trustee. Although Mayer et al (1995) do not represent reward in their model, potential rewards are built into their conceptualization of risk. If the task is highly valued and no one else can perform it, the trustor's reward from the interaction is large. If the task is not valued or there are many alternatives for accomplishing it, the reward is small.

Model validation

No model of inter-personal trust has yet been validated. The Mayer, Davis Schoorman model has been used in a study of employee trust for top management (Mayer and Davis, 1999). The study used group level measures of trust rather than dyadic measures. The goal of this study was to investigate the relationship between perception of the appraisal system and the level of employee trust for management, not the validation of the model.

Dyadic Trust Scale development

I conceptualize trust as a property of the relationship between two actors that has a directional quality, as in "**A** trusts **B**". Trust also has an object, as in the example, "**A** trusts **B** about **X**" (Hardin, 2000). The need for questions that identified a specific person and the performance of a specific task made most existing trust scales unsuitable. In addition, it was necessary to differentiate our measure of trust from perceived trustworthiness and our measure of the dimensions of perceived trustworthiness, care, ability or integrity. For example, the question "To what extent do you think that Person B is competent?" is a better measure of perceived trustworthiness. Since perceived trustworthiness is an antecedent to trust in the model, asking such questions would confound the measures.

Our definition of trust is the willingness to accept the risk based upon the expectation that another will perform, *irrespective of the ability to monitor or control that other party*. Since one of the indicators of low trust is a higher level of checking or monitoring of work progress (e.g. Strickland, 1958), I used checking as a behavioral

measure of the attitude trust. Therefore, I measured the extent to which the trustor reported checking on or verifying the work of the trustee, or feeling the need or desire to do so.

Similarly, I developed dyadic measures for perceived trustworthiness, and perceived performance.

Identifying key characteristics of project-based learning environments as data sources for work-related studies

To investigate the development of trust in cross-functional, global teams, I studied student building design teams composed of an architect, a structural engineer, and a construction manager. The participants for this study were students in a Computer Integrated Architecture-Engineering-Construction (A/E/C) class organized by Stanford University in the United States (Fruchter, 1999), but with student participants from several countries. Such a project-based learning environment allows researchers greater access and control, which is necessary for the development of scales and testing of longitudinal models.

Using this research as a case study, I identified the key characteristics of problem-based learning environments when used as data source for work-related studies. The goal is to provide a means of accessing highly individualized PBL courses as a data source for work-related research.

Reader's Guide

Chapters 2, 3 and 4 will each be published as stand-alone book chapters or articles, and thus can be read independently. They have been placed in a sequence planned to enhance understanding for the reader when read sequentially.

Please note that, although the three papers are co-authored, I drafted the full text of all three papers and received the same amount of comments from the listed co-authors, as they would normally provide when reviewing draft chapters of a traditional dissertation.

Chapter 2 describes the development and testing of the model over three years of the research project. Chapter 3 extends the analysis to look at the similarities and differences between collocated and distributed dyads. Chapter 4 discusses the use of students in problem-based learning environments as a data sample for this type of study.

The final chapter, Chapter 5, provides the reader with a summary of the practical and theoretical contributions of my work and my suggestions for future research.

Chapter 2.

Trust In Cross-Functional, Global Teams*

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Abstract

With Internet technology and globalization, companies are rapidly adopting cross-functional, global teams, but little is known about the challenging new social environment created for team members. One challenge is the development of trust. To develop and test a model of inter-personal trust, we observed and surveyed 167 dyads across nineteen globally distributed student teams. Teams containing an architect, engineer and construction manager with entry-level education and work experience designed, analyzed and planned a $5 million construction project. We found that perceived trustworthiness (benevolence, ability and integrity) was associated with higher levels of trust but perceived performance mediated the relationship between perceived trustworthiness and trust. Our longitudinal analyses indicated general stability in perceived trustworthiness, perceived performance and trust, but there were some changes over time.

Trust In Cross-Functional, Global Teams

Imagine a construction firm with offices worldwide that has won a competition to build a prestigious hotel facility in Singapore worth over $100 million. They assign a world famous architect based in their London office to team up with a senior structural engineer from their design group in the San Francisco office, and they engage a general contractor based in Singapore to construct the hotel.

Such scenarios are commonplace today in the construction industry and are becoming increasingly common in other industries. These cross-functional, global teams provide great advantages by bringing the diverse skills of scarce specialists to bear on problems or projects that span traditional organizational boundaries, in such diverse areas as software development (Carmel, 1999), engineering (Hauptman and Hirji, 1999, Levinthal and Warglien, 1999), nursing (Ireson and McGillis, 1998), purchasing, and new product development (Brunelli, 1999). They are popular for change-orientated projects such as introducing "total quality" practices, business process reengineering, new product development and improvements to product or service quality (Bishop, 1999). Although companies are rapidly adopting the model of cross-functional, global teams (Jasswalla and Sashittal, 1999), little is known about the challenging new social environment that such teams create for team members (Maznevski and Chudoba, 2000).

One of the major challenges for members of cross-functional, global teams is the development of trust (e.g. Bishop, 1999). Trust develops on the basis of the trustor's personality, the history of the relationship, third-party information, shared category

membership, role expectations, and rule-based expectations (see Kramer, 1999). However, the process of developing trust on cross-functional, global teams may be hindered by the characteristics that define these teams (e.g. O'Hara-Devereaux and Johansen, 1994). Cross-functional, global teams are populated with members who have different training and may have conflicting priorities. They also are likely to interact primarily over mediating technologies rather than face-to-face thus finding it more difficult to share information, observe others' personalities and behavior, and develop rapport.

The irony is that trust may be particularly important on cross-functional projects because many sub-tasks are interdependent, with team members relying on the functional expertise of other team members. Trust is central to teamwork, leadership and organizational culture (Fairholm, 1994, Nicholas, 1993, Ryan, 1999). But, trust may be more difficult to establish in cross-functional, global teams because team members are less familiar with the goals, world-views, problem solving approaches, and methods of team members from other disciplines and other regional or national cultures. Geographic distance makes it even more challenging to create shared understanding (Cramton, 2001) and develop rapport (e.g. Kiesler and Cummings 2002).

Consistent with Rousseau and colleagues (Rousseau, Sitkin, Burt and Camerer, 1998: p. 395, see also Mayer, Davis and Schoorman, 1995), we define trust as "a psychological state comprising the intention to accept vulnerability based on positive expectations of the intentions or behavior of another." However, along with others, we assume that trust can only exist within a particular situation or action (see Gambetta, 1988, Bhattacharya, Devinney, & Pittultia, 1998). As Bigley and Pearce (1998) have

argued, it is not a question of "What is trust?" but rather "What trust and when?" Thus, we assume that the expectations of the intentions or behavior of another must be embedded in a particular situation.

In this paper, we synthesize the extant literature to develop a model of trust in cross-functional global teams and empirically test our model in 169 dyads across nineteen teams.

Cross-Functional Teams

A cross-functional team is a group of people with complementary skills who are chosen to achieve a common goal and are mutually accountable for the team's success (Katzenback and Smith, 1993). For example, each line of Harley-Davidson motorcycle is created by a team consisting of a program manager from the design community, a manufacturing lead, a purchasing lead and a marketing lead who work together to bring the product to market (Brunelli, 1999). Such mutual accountability coupled with specialization suggests high levels of interdependence. For example, in design/build projects the architect, engineer and construction manager are reciprocally interdependent – the design and planning activities are performed more or less concurrently (Thompson, 1967). This structure potentially shortens the length of time spent in planning and creates opportunities for joint problem solving, presumably resulting in buildings that are more attractive, safer, cheaper and completed sooner. Such strong interdependence requires trust (Shepard and Sherman, 1998, Shapiro, 1987), particularly in a cross-functional team, because other team members do not have the necessary skills to perform in the breech created by non-performing team members. Sometimes, as is the case with

structural engineering, cross-functional team members cannot legally substitute for each other.

Developing trust may be particularly difficult in cross-functional teams due to unshared goals and perceived differences in professional allegiance. Even though cross-functional team members work together to achieve shared project goals, people from different disciplines often have different functional objectives, priorities, and agendas (Jasswalla and Sashittal, 1999). For example, in a large construction project, the architect is responsible for the aesthetics of the building, the structural engineer for its structural soundness, and the construction manager for ensuring that it can be built on time and within budget. These functional goals often are in conflict and require a "give and take" type of problem solving to arrive at a solution that will satisfy the project goals and the goals of each discipline.

The cross-disciplinary composition of a cross-functional team also means that team members are less likely to perceive themselves as belonging to the same group or category, one of the factors that promotes trust (Brewer, 1996). Kramer, Brewer and Hanna (1996) propose that the strength and salience of identification with a group influences trust of other members. Social categorization (Tajfel, 1969) can lead to in-group bias resulting in higher perceived trustworthiness and enhance perceived similarity that may reduce perceived risk. In cross-functional teams, disciplinary differences may be particularly salient because of the importance people place on their own specialization (e.g. Schunn, Crowley and Okada, 1998). Thus, whereas task interdependence requires more trust between team members, the multi-disciplinary nature of these teams may make the development of trust more difficult.

Global Teams

The challenges confronting cross-functional teams are compounded when team members are distributed around the globe. Trust can become increasingly difficult to develop when team members have few opportunities to interact face-to-face, rely heavily on technology to mediate their interactions, and face cultural and language barriers. Geographic distribution reduces the amount of time that team members spend in the presence of one another and therefore is likely to hinder the development of rapport and trust (see Kiesler and Cummings 2002). Physical proximity and face-to-face interaction may be crucial for developing and maintaining trust (see Nohria and Eccles, 1992). Collocation also can reinforce social similarity and highlight obligations that individuals have to one another (Latane, Liu, Nowak, Bonevento, and Zheng, 1995). When teams are geographically distant and rely on mediating technologies to interact, information may flow less easily between team members (see Hollingshead, 1996), team members may not develop the same understanding of the information that is shared (e.g. Cramton, 2001), and team members may assume the worst of distant team members (Cramton 2002). For these reasons, when observing geographically distributed teams, Armstrong and Cole (2002) noted that distant team members had a more difficult time reconciling issues. These findings are consistent with media richness (Daft, Lengel, and Trevino, 1987) and social presence (Short, Williams, and Christie, 1976) theories which argue that mediating technologies will impoverish the communication process and result in less inter-personal affection and trust.

In addition to spanning geographic distances, global teams are likely to be composed of people from different cultures with different basic assumptions (Schein,

1991). The diversity of team members could make the development of trust difficult (Williams and O'Reilly, 1998) because others' perspectives and behaviors are more easily misinterpreted (see Olson and Olson, 2000). Thus, we expect that global teams will have difficulty reconciling issues that arise and developing and maintaining trust.

In an examination of trust development in globally distributed teams, Jarvenpaa and Leidner (1999) reported that teams developed "swift trust," but that it may have been fragile and temporary. Theories of "swift trust" argue that, due to roles, trust does not start at zero in new relationships (Meyerson, Weick & Kramer, 1996). In their temporary (6 week duration) teams, few teams were able to develop trust if trust was not established from the beginning. In summary, Jarvenpaa and Leidner argue that trust can be established in globally distributed teams, but it may be fragile and early interactions between team members are crucial.

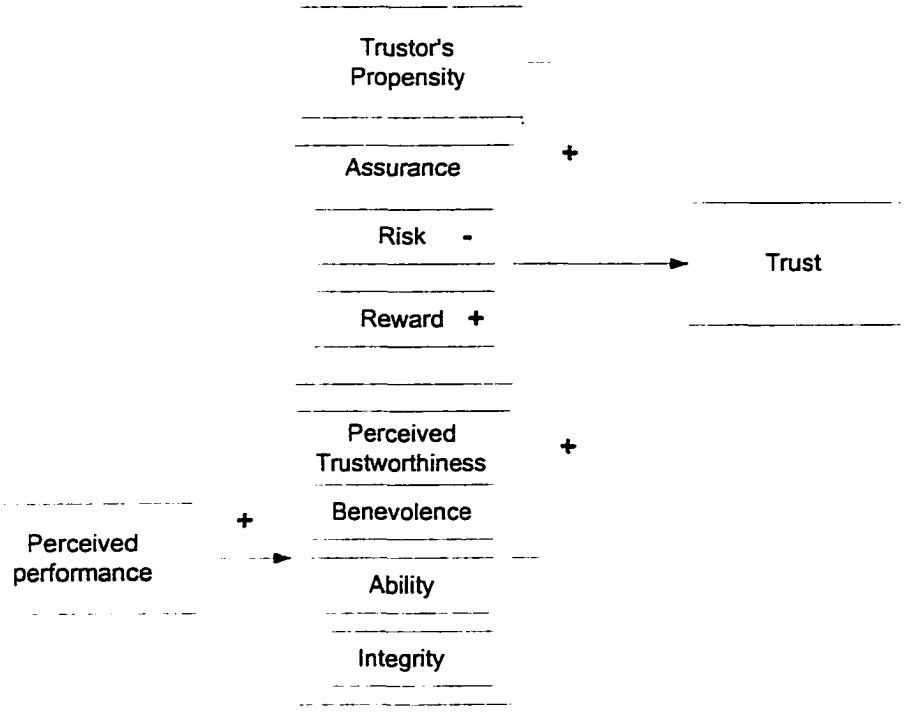
Trust Development in Cross-Functional Global Teams

Although the process may be more difficult, we argue that trust in cross-functional, global teams can develop as it does in traditional teams. We therefore rely on existing models of trust development to generate our predictions. In particular, we have used the model built by Mayer et al (1995) as a point of departure. In their integrative model of organizational trust, Mayer and his colleagues argued that trust is a function of the trustor's propensity to trust and the trustor's perception of the trustworthiness of the trustee (composed of perceived ability, benevolence, and integrity). They further argue that the trustor's perception of risk will affect the extent to which the trustor is willing be vulnerable to the behaviors of the trustee. Finally, they propose that the outcomes of risk

taking will affect the trustor's perception of the trustworthiness of the trustee in the future.

Our model also relies on the trustor's propensity to trust (general trust), the trustor's perception of the trustworthiness of the trustee, and the trustor's perception of risk. We, however, add several components to the model. First, we argue that perceived performance, which is more specific than outcomes, is an important behavioral measure on which people rely to determine trustworthiness. Second, in addition to considering their own risk, we argue that trustors take into account the potential rewards of trusting the trustee. Our model of trust development is pictured in figure 2.1 and described in detail below.

Figure 2.1. The proposed model of trust development in cross-functional global teams.



Trustor's propensity

Disposition-based trust theories propose that trust develops based on a person's general nature as a trusting or non-trusting person (Rotter, 1971). The trustor's propensity to trust (also referred to as general trust and dispositional trust) is a characteristic of the trustor, independent of the situation or characteristics of the trustee. The trustor's propensity to trust may be particularly important in global teams because people with different cultural backgrounds may vary in their propensity to trust others (e.g., Hofstede, 1980).

H1: The higher a trustor's propensity to trust, the more the trustor will trust members of his/her team.

Risk and Reward

Consistent with others, we posit that the situation faced by the trustor contributes to his or her willingness to trust. We argue that trust is partially determined by the potential risk and reward faced by the trustor and the trustee. Many scholars have argued that risk is a necessary pre-condition for trust (Coleman, 1990, Rousseau et al, 1998). Several have considered risk so central to the trust decision that they have incorporated the concept of risk into their definition of trust (e.g. Shapiro, 1987, Sheppard and Sherman, 1998). For example, Coleman (1990: 91) defined trust as "an incorporation of risk into the decision of whether or not to engage in the action." The value at risk for the trustor equates to the value of what will be lost if the trusted person does not perform. Failure to perform by the trusted person may result in loss of overall project quality, time invested, or reputation if the failure interferes with the trustor's ability to meet obligations. Perceived risk may be mitigated by social controls such as binding contracts,

procedural norms and so forth (Shapiro, 1987) or exacerbated by uncertainty and lack of information. Risk may be perceived as particularly high in cross-functional, global teams because of task interdependence, the inability of team members to perform the job of others, and the difficulty of getting information about team members' performance.

We also propose that the potential for reward is an important situational consideration for the trustor. Although Mayer et al (1995) do not represent reward in their model, potential rewards are built into their conceptualization of risk. If the task is highly valued and no one else can perform it, the trustor's reward from the interaction is large. If the task is not valued or there are many alternatives for accomplishing it, the reward is small. Yamagishi and Yamagishi (1994: p. 129) define assurance as "a perception of the incentive that leads the interaction partner to act cooperatively". We argue that assurance is a combination of both risk and reward such that lower levels of risk and higher levels of reward increase the extent to which the trustor can expect to receive value from the interaction and trust a team member.

H2: To the extent that trustors perceive low levels of risk and high levels of reward for themselves, they will trust their team members more.

Perceived Trustworthiness

Although the word trust is sometimes used when describing perceived trustworthiness (Hardin, 2000), it is important to distinguish between perceptions of trustworthiness and trust because trust may be influenced by factors other than the trustworthiness of the trustee. Perceived trustworthiness is a multifaceted construct (Barber, 1983, Mishra, 1996, Rempel, Holmes and Zanna, 1985). Consistent with the

Mayer et al (1995) model, we use three dimensions of perceived trustworthiness; benevolence, ability, and integrity.

Benevolence is described by Mayer and colleagues (Mayer et al, 1995: 719) as "the perception of a positive orientation of the trustee toward the trustor." Benevolence can be the outcome of goal alignment or "encapsulated interest" (Hardin, 2000) or the confidence derived from mutually compatible interests (Das and Teng, 1998). Benevolence is similar to McAllister's (1995) conception of affect-based trust – trust grounded in reciprocated concern from the other party.

Ability refers to the extent that the trustee has the skills and resources needed to perform the task and may be an essential element in determining trust (e.g. Butler 1991, Butler and Cantrell 1984, Sitkin and Roth, 1993). No matter how diligent a team member, if he or she does not have the ability to accomplish the goal then the likelihood of success is slim and trust not warranted. This dimension is similar to McAllister's (1995) conceptualization of peer reliability and dependability, which depend on the trustee's ability to deliver as promised (or expected). Consistent with Mayer and colleagues (Mayer et al, 1995), we have conceptualized ability as specific to the task and situation rather than as generalized expertise.

The third dimension, *integrity*, refers to the honesty and moral character of the trustee as perceived by the trustor. This is consistent with Mayer et al's (1995: 719) definition of integrity as "the trustor's perception that the trustee adheres to a set of principles that the trustor finds acceptable" and with Butler's (1991) dimension by the same name. Trustees who are perceived as having integrity are seen as more likely to

behave in honorable ways toward team members. Thus, to the extent that trustors see teammates as high in integrity, they are more likely to perceive them as trustworthy.

We posit that benevolence, ability, and integrity compose perceived trustworthiness and lead to increased trust in cross-functional, global teams.

H3: To the extent that the trustor perceives his team members as caring, capable, and of high integrity, s/he will trust them more.

H4: Perceived trustworthiness composed of benevolence, ability, and integrity) will increase trust between team members.

Perceived Performance

Trust is often represented as a static, binary (trust exists or does not exist) variable but comparative histories give evidence that trust changes over time (Rousseau at al, 1998). One important basis for trust is the history dependent process in which "trust between two interdependent actors thickens or thins as a function of their cumulative interaction" (Kramer 1999, p 575). The process resulting in the change in trust over time begins when an individual's expectations about another party are confirmed or discredited by experience (Kramer, 1999). Thus, once a trustor is given the opportunity to observe a trustee's behavior, the trustor can evaluate the perceived performance of the trustee, the extent to which the trustee has followed through on the commitments made. Our dimension of perceived performance is similar to the "outcomes" variable in Bhattacharya, Devinney, and Pittultia's (1998) dynamic model that describes trust in terms of actions, outcomes and consequences. It is also similar to the dimension Mayer et al (1995) refer to as "outcomes." In both of these models the variable outcomes refers to the positive or negative results of trusting. Mayer Davis and Schoorman also propose

that outcomes will positively or negatively influence perceived trustworthiness. Expanding on these ideas, we argue that trustors will think their team members worthy of trust when the trustor perceives that his team members are performing as expected.

H5: When trustors perceive their team members as performing well in a given domain, perceived trustworthiness will increase.

Although there is evidence that trust changes over time, individuals rarely seek disconfirming information and may actually try to avoid it (Good, 2000) suggesting that trust, like first impressions (Chaiken & Eagley, 1998), may be resistant to change once established and thus stable over time (see Ring and Van de Ven, 1994). In cross-functional, global teams, disconfirming information may be less available and less visible (see Cramton 2002). Thus, members of these teams may form an opinion about the trustworthiness of their team members and be more resistant to changing their opinion. This is consistent with the finding of Jarvenpaa and Leider (1999) that global teams who develop trust in the formative stages of the team are more likely to sustain high levels of trust.

H6: Trustor's perceptions of team members' trustworthiness, perceptions of team members' performance, and trust of their team members will be stable over time.

Method

To evaluate the development of trust in cross-functional, global teams, we studied student construction design teams composed of an architect, a structural engineer, and a construction manager. On average, students had taken 12 courses in architecture, structural engineering, or construction and had 8 months of full-time work experience in

the domain. We observed the teams over three consecutive years and collected survey data for the last two years.

The Architecture/Engineering/Construction Project

The participants for this study were students in the seventh and eighth generation of a Computer Integrated Architecture-Engineering-Construction (A/E/C) class organized by a West Coast University in the United States (Fruchter, 1999). Masters students drawn from United States, European and Asian universities and from three different disciplines—architecture (A), engineering (E), and construction management (C)—worked in globally distributed teams for four months to design a five million dollar building according to a client's specifications. The graduate students were assisted by undergraduate "apprentices" and mentored by globally distributed professionals working in each discipline.

To facilitate assignment to groups, students were randomly assigned a skill profile (e.g. experience working in an earthquake zone) during an initial face-to-face meeting attended by all students. Each project had a specific characteristic, such as being located in an earthquake zone. In an icebreaking exercise, students identified and joined the project that best suited their randomly assigned skill profile (e.g. those with experience working in earthquake zones were likely to join projects with a building to be located in an earthquake zone). By chance, each team included at least one member who was not collocated. By necessity, each team had to have at least one team member from each discipline, architecture, engineering and construction management. After the two-day project launch, teams did not meet again face-to-face until the final presentation four months later. Distributed team members communicated mainly through computer-based

Internet applications. Internet meeting applications allowed audio and video communication and desktop file sharing. Internet message applications allowed synchronous message transfer between two or more parties. An Internet application developed for the course facilitated the posting and retrieval of messages and files. Collocated team members used face-to-face meetings as needed.

Data Collection

Data were collected over three years. In year 0, we observed and videotaped (from a single location) the distributed team meetings and conducted group discussions with participants in each of the three disciplines to develop a general understanding of how trust developed and identify strategies for data collection. In year 1, we studied seven teams composed of three to four team members each, distributed across six locations in three countries – the United States, the United Kingdom, and Slovenia. All team members participated in the research. We observed and videotaped one side of the distributed team meetings, conducted structured interviews with individual team members, and collected survey data at two points in time. During the first 2 weeks of the project, we administered an online survey with questions about work experience, the number of courses taken in each discipline, and general trust. Three months into the project, we asked each team member to rate each of his or her other team members on trustworthiness (benevolence and ability) and to indicate the extent to which they checked on the work of each other team member (our measure of trust). From this survey, we received 61 usable dyadic (directional) responses (e.g. responses from A about B). Information on the trustor's perceived risk and reward and the trustor's perception of the trustee's risk and reward were gathered from structured interviews

conducted during the last month of the 4 month project. The interviews were video recorded and notes transcribed.

In year 2, we conducted online surveys and structured interviews with 12 teams composed of three to four team members each, distributed among 10 locations in six countries - the United States, Switzerland, Holland, Germany, Slovenia, and Japan. Again all team members participated in the research. As in year 1, a survey during the first week of the project asked questions about the number of courses taken and work experience in each discipline. We also added questions about students' perceptions of their own risks and rewards associated with the project. Approximately one month later and three months later, we distributed dyadic surveys similar to that described in year 1 which yielded 108 dyadic responses. However, in year 2 for the survey at three months, we included several questions to measure each team member's assessment of their other team members' integrity.

Measures

Dependent Variables

Our primary dependent variable of interest is trust. I conceptualize trust as a property of the relationship between two actors that has a directional quality and an object of trust, as in A trusts B about X (Hardin, 2000). The need for questions that identified a specific person and the performance of a specific task made most existing trust scales unsuitable. In addition, it was necessary to differentiate our measure of trust from perceived trustworthiness and our measure of the dimensions of perceived trustworthiness, care, ability or integrity. For example, the question To what extent do you think that Person B is competent? is a better measure of perceived trustworthiness.

Since perceived trustworthiness is an antecedent to trust in the model, asking such questions would confound the measures. Our definition of trust is the willingness to accept the risk based upon the expectation that another will perform, irrespective of the ability to monitor or control that other party. Since one of the indicators of low trust is a higher level of checking or monitoring of work progress (e.g. Strickland, 1958), I used checking as a behavioral measure of the attitude trust. Therefore, I measured the extent to which the trustor reported checking on or verifying the work of the trustee, or feeling the need or desire to do so. To create a measure of checking, we averaged across four items in the dyadic survey (see figure 2.2) that were rated on a 5-point scale with high amounts of checking rated more highly. This resulted in a variable ranging from 1 to 5 with high scores indicating low levels of trust. The scale reliability for the four items was high (alpha=.82 in year 1 and alpha=.77 in year 2). These data were taken from the dyadic surveys administered three months into the project during year 1 and one and three months into the project during year 2.

Figure 2.2. Scale items for years 1 and 2. (* Indicates items were reverse coded)

Trust Behavior – Checking
1. How often have you needed to check/ask to see if this team member had completed her/his commitments?
2. How often have you counted or compared to see if this team member was contributing to the group?
3. How often have you worried about this team member's performance?
4. How often have you checked on this team member's progress on the deliverables promised?

Propensity (General trust)
1. Most people are basically good and kind
2. Most people are trustworthy
3. Most people are basically honest.
4. I am trustful.
5. Most people are trustful of others.
6. Most people will respond in kind when they are trusted by others.
7. People are always interested only in their own welfare.*
8. No matter what they say, most people inwardly dislike putting themselves out to help others.*
9. One can avoid falling into trouble by assuming that all people have a vicious streak.*
10. In this society, one does not need to be constantly afraid of being cheated.*
11. People usually do not trust others as much as they say they do.*
12. In this society, one has to be alert or someone is likely to take advantage of you.*

Risk (Year 1)
Do you feel that you are at risk if your team mates do not perform?
What is at stake for you if your team mates do not do their job?
What would happen if a team mate just refused to perform?

Reward (Year 1)
1. What reasons did you have for taking on the project?
2. How important were those reasons?

Risk (Year 2)
1. To what extent do you feel at risk if one team member does not perform?
2. How much is at stake for you (what do you have to loose) if one team member does not do their job?
3. How serious will it be if one team member refuses to perform through most of the project?

Reward (Year 2)
What goals do you do you hope to achieve with this project? (Not directly used)
2. How important are those goals?

Perceived Trustworthiness: Benevolence
1. How often has this team member made an extra effort to make your job easier?
2. How often has this team member listened carefully to hear your problems or concerns?
3. How often has this team member notified you when she could not meet a commitment?
4. How often has this team member passed on new information or ideas that may be helpful to you or the group?
5. How often does this team member check to make sure that communication was received or understood?

Ability
1. How often has this team member exhibited technical or project competence?
2. How often have you noticed that team member exhibit professional behavior?

Integrity
1. To what extent is this team member Honest/Dishonest?*
2. To what extent is this team member Virtuous/Sinful?*

Perceived performance
1. How often did this team member follow-through on work commitments?
2. How often did this team member complete work commitments on time?
3. How often did this team member fail to follow-through on work commitments? *
4. How often did this team member fail to complete work commitments on time? *

Independent Variables

The primary independent variables of interest in this study are propensity (general trust), trustor's risk and reward, perceived trustworthiness (benevolence, ability, and integrity) and perceived performance. Propensity to trust was measured using the Rotter scale for general trust (1971) modified by Yamagishi, Cook and Watabe (1998). Propensity was taken from the background survey administered during the first two weeks of the project in year 1. Because propensity resulted in low scale reliability (alpha=.47) and did not predict trust in year 1, it was not measured in year 2.

In year 1, perceived risk and reward were assessed from questions asked in the interviews (3 months into the project), but in year 2 similar questions were included in our demographic survey so that we could assess perceptions of risk and reward as early in the project as possible. Thus, in year 1, each participant's response to the risk and reward questions (see figure 2.2) were coded from the interview transcripts. The coder evaluated the respondent's perceived level of risk and reward as either low (1), medium (2), or high (3). To match the scale used in year 1, the 5-point risk and reward values in year 2 were rescaled as 1 or 2=1, 3=2, and 4 or 5=3.

Perceived trustworthiness was measured by perceived benevolence, ability, and integrity reported by the trustor about the trustee in the dyadic surveys. All items are listed in figure 2.2 and were measured using a 5-point scale with 5 equal to higher levels of benevolence, ability, or integrity. Benevolence was created by averaging across 5 items asking about the extent to which the trustee demonstrated sensitive and helpful behaviors that demonstrated concern for the trustee (alpha=.83 in year 1, alpha=.80 in year 2). Ability was created by averaging across 2 items asking about the extent to which

the trustee had exhibited technical, professional, and project level competence (alpha=.77 in year 1, alpha=.73 in year 2). Our last dimension of perceived trustworthiness, integrity, was only measured in year 2. Integrity has been conceptualized in many different ways including values congruence (e.g. Sitkin and Roth, 1993), consistency (e.g. Butler, 1991), and character (e.g. Gabarro, 1978). Consistent with Mayer et al (1995), we operationalized integrity as virtuosity and honesty as perceived by the trustor. This conceptualization was consistent with two questions from McCroskey's (1966) scales for source credibility. We therefore adopted these measures (see figure 2.2) with a resulting scale reliability of alpha=.67.

Perceived performance was measured based on the trustor's evaluation of the extent to which each team member followed through on commitments and completed work on schedule (see figure 2.2). Each of the items was measured on a 5-point scale where 5 equated to high levels of perceived performance. This 2-item scale resulted in a scale reliability of .87 in year 2. Perceived trustworthiness and perceived performance were taken from the dyadic surveys administered at one and three months into the project during year 2.

Analysis

We tested our hypotheses using linear regression models with ordinary least squares estimation (OLS). We anticipated a problem with autocorrelation – the correlation between values of the same variable across different cases. For example, my trust of you is related to your trust of me. Theories of trust based upon reciprocity (Creed and Miles, 1996: 19) suggest that the level of trust between two people is positively related, the more **A** trusts **B**, the higher is **B's** trust of **A**. That could cause a problem with

first order autocorrelation of the data between dyads. In both year 1 and year 2, the Durbon-Watson (Hamilton, 1992) test statistic (d) for correlation between the value of checking of the trustor and the trustee was higher than the upper limit (d=1.88 in year 1 and d=2.14 in year 2) suggesting no positive first-order autocorrelation among the errors. Thus, the reciprocal nature of trust does not appear to be significant in either year.

We also used the estimation procedure of AMOS (Hoyle, 1995, Byrne, 2001) to construct a structural equation model (SEM) to simultaneously observe the effects and changes of variables over time. The AMOS SEM is a test of goodness of fit between the data and the proposed model. The null hypothesis is that the model does not fit. Therefore, a low p value indicates that null hypotheses can be accepted, the model does not fit. A high p value indicates that the null hypotheses, that model does not fit, can be rejected. Our goal was to test hypotheses 6 that perceived trustworthiness, perceived performance and trust has some level of stability between month one and month three of the project in year 2. Hence we adopted a strictly confirmatory analysis approach (Joreskog, 1993). To maintain the same variables as in our multivariate regression models, we choose not to construct latent variables because isolating the measurement error in the indicator variables (Hoyle, 1995) was not our goal and could alter the values of the latent variables at the two points in time. Two potential problems with our data, a small sample size and non-normal distributions of variables, tend to overestimate the χ^2 statistic and hence can lead to rejection of suitable models (Byrne, 2001). We therefore used bootstrapping to provide a greater degree of accuracy in assessment of model fit statistics (Byrne, 2001).

Results

Year 1

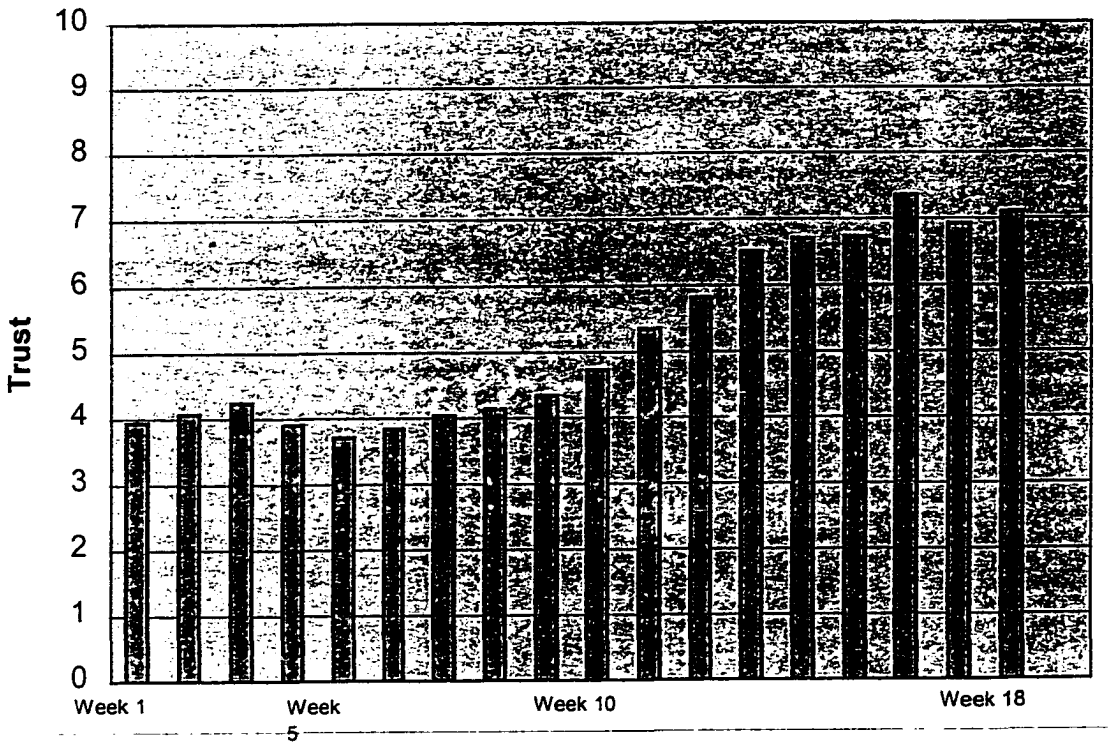
During discipline-based group discussions, members of each profession said that they would trust a member of their own profession more than one of the other professions, supporting our assertion that developing trust may be more challenging in cross-functional teams. The architects felt that architects were "inherently more trustworthy" since the architect has to coordinate the design team. The structural engineers said that the structural engineer must be trustworthy or the building would fall down. One construction manager jokingly said, "architects are useless" but the construction managers all laughed at the joke. These comments supported our intuition that trust would be more difficult to develop in cross-functional teams.

One behavior that was reported to build trust was making "personal sacrifices for the good of the team." Interruptions to work caused by lack of discussion and "seeing someone do something to save himself" were described as severely damaging trust. International differences in holidays that were not discussed also caused problems. Several teams did not coordinate the spring break and left team members wondering where they were for two weeks. Overall, being physically and temporally distributed (e.g. being in different time zones) and relying on technology reportedly made trust more difficult. These stories can be seen as examples of benevolence, competence and integrity, which support hypothesis 3.

In the interviews, team members were asked to draw a graph of the trust relationships in the teams to show how the level of trust increased or decreased during the time of the project. Figure 2.3 shows the average of all teams in year 1 across the four-

month project. As observed by Sheppard and Sherman (1998) and McKnight, Cummings and Chervany (1998) the level of trust does not start at zero. In fact, only one respondent began drawing the graph at zero and most graphs indicated an increase in trust suggesting that trust may develop over time.

Figure 2.3. Average level of perceived trust as drawn by participants in year 1.



The descriptive statistics for and correlations between quantitative variables for year 1 are reported in table 2.1. On the whole, participants reported moderate levels of general trust (M=3.03, SD=.55 on a 5-point scale), risk (M=1.92 on a 5-point scale) and reward (M=2.71 on a 5-point scale). Our dependent variable, checking, suggests that team members had relatively high levels of trust for their team members and did not spent much time checking on the work of others (M=1.35 on a 5-point scale). Higher levels of checking were significantly and negatively correlated with benevolence (r=-.43, $p < .001$), but not ability (r=-.21, n.s.) It is interesting to note that risk correlates with general trust (r=.44, $p<.01$), reward (r=.31, $p<.05$), and perceived trustworthiness (r=.29, $p<.01$).

Table 2.1. Descriptive Statistics and Correlations for Variables in Year 1 (N=61)

Variable	Mean	Std Dev.	1.	2.	3.	4.	5.	6.	7.
1. Checking	1.35	.60							
2. General trust	3.03	.55	.12						
3. Risk	1.92	.74	.16	.44**					
4. Reward	2.71	.67	.14	-.06	.31*				
5. Benevolence	3.32	.84	-.43***	.14	.25+	.06			
6. Ability	3.57	.95	-.21	.07	.27+	.24+	.26*		
7. Perceived trustworthiness	3.45	.71	-.39**	.12	.29*	.15*	.77***	.82***	
8. Perceived Performance	4.09	.65	-.70***	-.14	-.10	.07	.47***	.23+	.43***

+ p <.10 * p < .05 ** p < .01 *** p < .001

In hypothesis 1, we argued that people with a propensity to trust others would trust their team members more. We therefore expected a negative relationship between general trust and checking. Our data provided little support for this hypothesis. General trust was negatively (though not significantly) related to checking (β=-.10, n.s). Because of the low reliability of the measure we excluded general trust from analyses in year 2. We also hypothesized that the trustor's low level of perceived risk and high level of perceived reward would increase their trust of other team members (H2). The risk results were in the predicted direction (β=.18, n.s.), but the reward results were not (β=.08, n.s.), thus providing little support for hypothesis 2 (see table 2.2, model A).

Table 2.2. Comparison of OLS estimates (standardized beta values) of checking behavior for year 1, Month 3.

	Model A	Model B	Model C	Model D
Intercept	+	*	**	***
General trust	-.10	.03	.01	-.10
Risk	.18	.23	.23	.12
Reward	.08	.12	.14	.16
Benevolence		-.36 *		
Ability		-.10		
Perceived trustworthiness			-.41**	-.08
Perceived performance				-.64 ***
Adj. R-squared	-0.01	0.11	0.12	0.44
Model F	0.70	2.23 +	2.68*	8.78 ***
Degrees of freedom	3, 47	5, 45	4, 46	5, 45

˙ p <.10 * p < .05 ** p < .01 *** p < .001

In our third hypothesis, we argued that perceived benevolence, ability, and integrity would result in higher levels of trust. In year one, we have only measures of benevolence and ability so those are included in model B (table 2.2). Consistent with our hypothesis, it appears from model 3A that perceived benevolence is negatively related to checking (β=-.36, p<.05), suggesting moderately higher levels of trust. Ability had a negative, but not significant, relationship to checking in model B (β=-.10, n.s.).

Hypotheses 4 proposed that perceived trustworthiness (composed of benevolence, ability, and integrity) increases trust. When benevolence and ability were combined in Model C their significance increased (β=-.41, $p<.01$), providing initial support for Hypothesis 4. As predicted in hypothesis 5, perceived performance had a positive relationship with perceived trustworthiness, although it was not significant (r=-.23, $p<.10$).

Year 2

In year two, we collected data at three points in time to enable tests of our longitudinal hypothesis (H6). We also collected data on integrity so that we could fully test hypotheses 4, 5 and 6, removed our measure of general trust because we found that it provided little explanatory power in year 1, and increased the size of our sample. The descriptive statistics for and correlations between our variables for year 2 are provided in table 2.3. Consistent with year 1, the correlation between checking and benevolence (r=-.41, $p<.001$) was negative and significant in year 2 (at month three) as were the relationships with ability and integrity (r=-.55, $p<.001$ and r=-.50, $p<.001$, respectively). As expected, risk was positively correlated with checking (r=.32, $p<.01$) and reward had a negative relationship (r=-.19, $p<.05$), more clearly supporting hypothesis 2. Again, as predicted in hypothesis 5, perceived performance had a highly significant, positive relationship with perceived trustworthiness (r=-.50, $p<.001$).

Table 2.3. Descriptive Statistics and Correlation Table for Year 2, Month One (1) and Month Three (3) (N=104)

	Mean	Std. Dev.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11	12.
1. Checking (1)	2.53	0.86												
2. Risk	2.10	0.43	.17+											
3. Reward	2.46	.56	-.09	.04										
4. Benevolence (1)	3.53	0.78	-0.16	-.10*	.07									
5. Ability (1)	3.62	0.88	-0.22*	-.19*	.04	0.65***								
6. Trustworthiness (1)	3.58	0.75	-0.21*	-.16+	.06	0.89***	0.92***							
7. P'd performance (1)	3.91	0.81	-0.45***	-.20*	.23*	0.49***	0.57***	0.59***						
8. Checking (3)	2.42	0.70	0.32***	.30**	-.19*	-0.42***	-0.38***	-0.44***	-0.44***					
9. Benevolence (3)	3.54	0.74	-0.08	.03	.03	0.59***	0.43***	0.55***	0.32***	-0.41***				
10. Ability (3)	3.84	0.81	-0.14	-.14	.05	0.55***	0.60***	0.64***	0.53***	-0.55***	0.76***			
11. Integrity (3)	4.36	0.94	-0.15	-.40***	-.02	0.14	0.26**	0.22*	0.29**	-0.50***	0.32***	0.47***		
12. Trustworthiness (3)	3.91	0.69	-0.14	-.23*	.02	0.50***	0.51***	0.56***	0.46***	-0.60***	0.82***	0.89***	0.76***	
13. P'd performance (3)	3.99	0.68	-0.04	-.11	.17+	0.40***	0.50***	0.50***	0.50**	-0.66***	0.62***	0.78***	0.50***	0.76***

[1] N =85 , + p <.10 * p < .05 ** p < .01 *** p < .001

To test our hypotheses against the data collected in year 2, we again conducted OLS regression analyses predicting checking using the data collected at 3 months into the project. To test our hypotheses that trustor's perceived risk would increase trust and reward (H2) would decrease trust, we combined these variables into a regression model predicting checking (table 4, models A1 and A3). Trustor's perceived risk was positive, but not significant (β=.16, $p < .10$), and reward was negative and significant (β=-.19, $p<.05$), providing some support for hypotheses 2.

Table 4. Comparison of OLS estimates (standardized beta values) of checking behavior for year 2, Month 1 (1) and Month 3 (3) [1]

	Model A1	Model A3	Model B1	Model B3	Model C1	Model C3
Intercept	***	***	***	***	***	***
Risk	.14	.16 +	.14	.18 *	.09	.21**
Reward	-.08	-.19 *	-.08	-.20 *	.02	-.13+
Benevolence	-.03	-.08				
Ability	-.17	-.34 **				
Integrity		-.25 **				
Perceivedd trustworthiness			-.18+	-.55 ***	.10	-.17
Perceived performance					-.49 ***	-.49***
Adj. R-squared	.03	.40	.04	.41	.18	.50
Model F	1.91	15.00 ***	2.47+	24.83 ***	6.76 ***	26.79***
Degrees of freedom	4, 100	5, 98	3, 101	3, 100	4, 100	4, 99

[1]N = 106 [+] p <.10 * p < .05 ** p < .01 *** p < .001

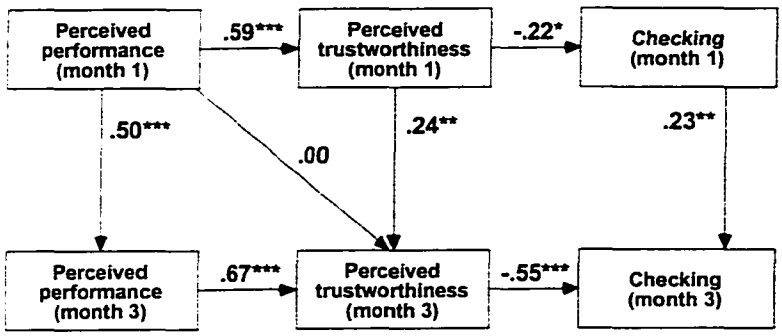
Next, we examined the three dimensions of perceived trustworthiness – benevolence, ability, and integrity – hypothesized to increase trust (H3 and H4). As indicated in model A3, our analysis suggests a strong and negative relationship between ability and checking (β=-.34, $p<.01$) and between integrity and checking (β=-.25, $p<.01$) thus providing support for our argument that perceived ability and integrity would increase trust. Although the relationship between benevolence and checking also was negative (β=-.04, n.s.) this relationship was not significant. Thus, partial support is provided for hypothesis 3. We then created a perceived trustworthiness measure that combined benevolence, ability, and integrity (see table 4, model 4B) to test hypothesis 4. In model B3, it can be seen that perceived trustworthiness is significantly and negatively related to checking (β=-.55, $p<.001$), providing support for our hypothesis that perceived trustworthiness (composed of benevolence, ability, and integrity) would lead to higher levels of trust. The adjusted r-square for model B3 was .40, suggesting that perceived trustworthiness explain a significant amount of the variance in checking, and thus trust, in cross-functional, global teams. We then added perceived performance to models C1 and C3 to find that it, too, was significant in predicting trust (β=-.49, $p<.001$), although when added to the model, perceived trustworthiness was no longer significant (β=-.17, n.s.).

Longitudinal Model

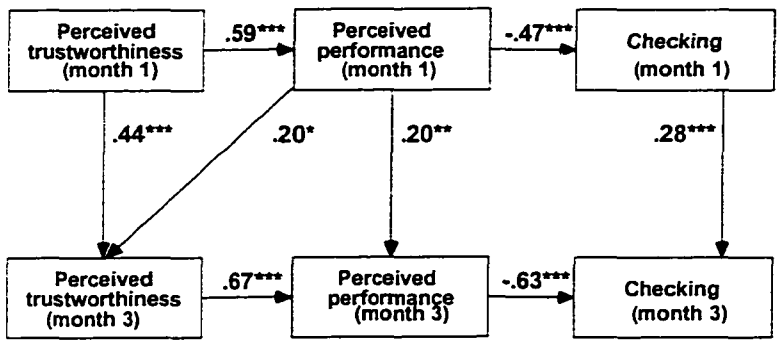
We predicted that trust will be stable over time (H6), but that there will be some change related to perceived performance (H5). To test these hypotheses, we created a structural equation model (AMOS) (see figure 2.4, model A) that reflected the predicted relationships. However, this model was an extremely poor fit to the data χ^2 (7, N = 104) = 67.74, $p<.001$.

Figure2. 4. Structural equation model estimation of standardized coefficients.

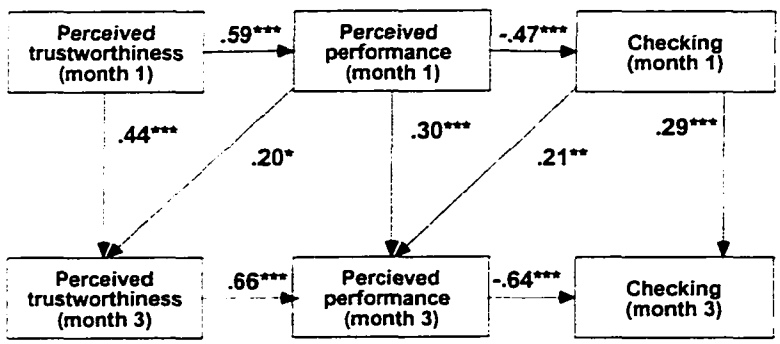
Model A (N =108)
chi square = 67.740 df = 7 p = .000



Model B (N=108)
chi square = 13.057 df = 7 p = .071



Model C (N=108)
chi square = 3.698 df = 6 p = .717



In conducting a mediation analysis based on regression models, we saw some evidence that during a single time period, perceived performance might be mediating the relationship between perceived trustworthiness and checking rather than the reverse. We therefore tested a revised model (figure 2.4, model B). The model provided a better fit to the data χ^2 (7, N = 104) = 13.05, p = .07. The Bollen-Stine bootstrap provided increased evidence of model fit (p = .08). This analysis suggests that during a single time period perceived trustworthiness (benevolence, ability, and integrity) may affect the trustor's *perception* of the extent to which the trustee is following through on commitments. That is, if people perceive their cross-disciplinary team members as trustworthy, they may believe that their team members are performing as expected. However, consistent with hypothesis 5, this analysis also indicates that perceived performance early in the project affects perceived trustworthiness later in the project suggesting that team members also are updating their perceptions of trustworthiness based on how their team members' behaviors match expectations.

The data provide strong support for hypothesis 6 – that perceptions of trustworthiness, perceived performance, and trust will be stable over time (see figure 2.4, model B). Perceived trustworthiness at month one strongly predicted perceived trustworthiness at month three. Perceived performance at month one predicted perceived performance at month three. And, checking at month one predicted checking at month three.

Modification indices indicated that a direct relationship between checking at time one and perceived performance at time two would improve the model fit. Doing so (see figure 2.4. model C) improved model fit χ^2 (6, N = 104) = 3.70, p = .72. Goodness of fit

indices also indicated a high level of fit (NFI = 0.998, INI = 1.0, CFI = 1.0). The new relationship between checking at month one and perceived performance at month four is highly significant ($p<.01$), suggesting that checking on one's team members may have the positive effect of increasing trust by providing confirming evidence that the team member is performing as hoped.

Although all of the dyads we analyzed were cross-functional, 31 of the dyads in year 2 were collocated. We do not have adequate data to thoroughly compare collocated with distributed dyads; however, we were able to compare 77 distributed with 31 collocated dyads by generating separate structural equation models for each. In the distributed dyads, trust at month one was more predictive of trust at month three ($p<.001$) than in collocated dyads ($p<.10$), suggesting that trust on cross-functional, collocated teams may change more over time compared with cross-functional, distributed teams. A simple comparison of trust scores from month 1 to month 3 suggests that cross-functional, collocated dyads appear to increase (19%) and decrease (16%) trust more so than do cross-functional, distributed dyads (only 9% increased and 10% decreased trust). A comparison of the two models suggests that model C (figure 2.4) fits better for distributed (χ^2 [6] = 3.12, p=.79) than for collocated dyads (χ^2 [6] = 5.15, p=.52) although both models fit reasonable well. These results argue for future work comparing trust development on collocated teams with trust development on teams that are geographically distributed.

Discussion

Our data suggest that trust develops on cross-functional, global teams and that models of trust development on traditional teams obtain for cross-functional, global

teams. Consistent with the model proposed by Mayer et al (1995), we found that perceived trustworthiness was associated with higher levels of trust. To the extent that participants viewed their team members as caring, capable, and of high integrity, they were less likely to check on their performance. The construct of perceived trustworthiness was strongly related to trust in our correlation analyses and our longitudinal analyses indicated that perceived trustworthiness at one month predicted perceived trustworthiness at three months into the project suggesting that first impressions may be particularly important in cross-functional, distributed teams.

We found that, not only does risk play a part in trust, but so, too does the trustor's perceived reward. In collocated teams, reward was associated with trust, whereas in distributed teams, risk was the significant factor. This extends the Mayer, Davis, & Schoorman model of trust by adding the dimension of reward and more completely accounting for the situation.

Contrary to models of trust development on traditional teams, our longitudinal analysis, also suggests that perceived performance mediates the relationship between perceived trustworthiness and trust. In these cross-functional, global teams, it appears that participants relied on their perceptions of their team members to evaluate the extent to which these team members met expectations. This suggests that perceiving team members as caring, capable, and of high integrity may affect trustor's perceptions of the extent to which team members have followed through and that evaluating the performance of cross-functional, global team members is not an objective matter. It may be difficult for team members to objectively evaluate the work of team members from other disciplines, particularly when they are not physically collocated and their work

process is not visible. We believe that this effect also may hold for collocated team members of cross-functional teams and distributed team members of teams that rely heavily on "knowledge work" – work that is cognitive and more difficult to evaluate objectively.

The results of our longitudinal analysis also suggest that people are observing the behavior of their team members and updating their perceptions of trustworthiness. Perceived performance at month one predicted perceived trustworthiness at month three, suggesting that one's behavior relative to expectations may contribute to higher perceived trustworthiness. This finding is consistent with theories of history-based trust that argue that trust is an outcome of cumulative interactions between individuals and is updated based on the trustor's experience of the trustee's behavior. These results also point to the central role of perceived (not necessarily actual) performance on cross-functional, global teams and may indicate that sharing information about work progress could help to build trust in these teams. This notion is consistent with O'Leary, Orlikowski, and Yates' (2002) study of trust and control in the Hudson Bay Company in which they found that providing regular reports to headquarters went hand-in-hand with establishing trust between these distant locations.

We also found that checking team member's performance at month one predicted perceived performance later in the project. Although we had not predicted this relationship, its presence provides further evidence that trust can build as a result of observing others' behavior. It also suggests that a lack of trust may have the positive outcome of enhancing trust in the long run to the extent that team members check on one another and gather information that affirms their trustworthiness. Although this finding

is contrary to Strickland's (1958) laboratory experiment showing that the more one checks on another's performance, the less one can learn to trust, our study differs from Strickland's in two important ways. First, our participants worked together over a four month period, much longer than the single day participants were engaged in his study and had the opportunity to learn from their monitoring. Second, our participants were working on a project that had personal meaning and consequences, so learning to trust and work well together may have been a higher priority. However, further research is needed to better understand how and on what basis trust is updated.

Taken together, the data indicate that perceived performance on cross-functional, global teams may have strong subjective and objective components. To the extent that people can observe and evaluate their team members' performance, they may use this information to recalibrate. However, to the extent that performance cannot be observed or evaluated, subjective evaluations may influence the development of trust.

The results of our study contribute to the nascent work on trust in globally distributed teams. Consistent with the work reported by Jarvenpaa and Leidner (1999), our results suggest that trust can develop in these teams and that what occurs early in the life of the team is crucial. Jarvenpaa and Leidner (1999) showed that early communication in distributed teams is important to trust. We suspect that early communication contributes to higher levels of perceived trustworthiness on global teams. Perceived trustworthiness may then affect perceptions of performance, thus strengthening trust. However, our work also suggests that information about behavior over time can affect trust and that trust may be fairly stable (as opposed to fragile) on these teams.

There are several limitations to the studies we report. First, the studies were conducted with student teams. Although these student teams operated in ways that are similar to teams in the construction industry, the teams were artificial in the sense that students were taking a class for which they would receive a grade, students were not employees of a firm, there were no immediate financial stakes, and they had little expectation of working with these team members on future projects. Researchers have identified relationships between trust and work group performance that are not simple and may be mediated by factors such as coordination and motivation (e.g. Dirks, 1999) and may be complicated by organizational level (Zaheer, McEvily, and Perrone, 1998). Such factors are more difficult to assess in student teams. In an ethnography of the Hudson Bay Company, O'Leary and his colleagues (O'Leary et al, 2002) describe the relationship between trust and control in a distributed work setting. In our student teams, no binding contracts were signed and students had few ways of controlling their peers. Although this may also often be the case in non-student work groups, the relationship between control and trust is an important one and emphasizes the importance of conducting further research in organizational settings to understand the complexity of trust between team members and determine the generalizeability of the results reported here.

Our tests of general trust in year 1 suggest that general trust is not a predictor of trust in these cross-functional, global teams. The general trust scale developed by Rotter (1971) has been used to predict trust in a number of studies (Yamagishi and Yamagishi, 1994, Yamagishi, Cook and Watabe, 1998). However, our measure of trust proved to have low reliability (alpha=.47), which may have contributed to problems with

prediction. We therefore believe it is necessary to conduct further research to determine the importance of general trust in predicting trust within cross-functional, global teams.

Another important characteristic of our study setting was that team members met face-to-face for two days at the start of the project. Others have argued for the importance of geographically distributed teams meeting early in the life of a project as a way of developing rapport and establishing a shared vision (Armstrong and Cole 2002, Kraut, Galegher, Fish and Chalfonte, 1992). However, many distributed teams never meet face-to-face. In those cases, we suspect that trust may be slower to develop and *swift trust* based on expectations about roles will be more crucial (see Jarvenpaa and Leidner, 1999). More research is needed to better understand the impact of face-to-face meetings on the development of trust in cross-functional, global teams.

Finally, the conclusions that we draw are for cross-functional, global teams, although the model we tested was derived from models developed for traditional (mono-functional, collocated) teams. Because we did not compare cross-functional, global teams with traditional teams, we are not able to draw conclusions about the differences that exist or about trust on traditional teams. However, we suspect that perceived trustworthiness is an important antecedent to trust in all teams. We also suspect that there may be differences between functionally homogeneous and cross-functional, global teams. In particular, we believe that cross-functional, global teams may be less able to gather information about their team members and may be less able to objectively assess their team members' performance. Thus, we believe that assessments of performance may be particularly subjective on these teams. We therefore anticipate that functionally homogeneous teams may rely more heavily on behavioral indicators of performance

rather than using perceptions about the trustworthiness of team members to assess performance.

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Chapter 3

Trust in Context: The Development of Inter-personal Trust in Geographically Distributed Work Teams *

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Abstract

Increased competition, globalization, and greater availability of communication technologies have led to an increase in the number of geographically distributed teams. The distribution of these teams creates new contexts for team members that may make it simultaneously more difficult and more important for members to trust one another. In this chapter, we used data from 108 dyads in 12 globally distributed student project teams to compare the development of trust in collocated and distributed dyads. We find evidence that trust is more stable in distributed dyads – it increases less, but it also decreases less than in collocated dyads. Members of distributed dyads appear to retain stable perceptions of their team members' trustworthiness that, in turn, affect their perceptions of their team members' performance. In contrast, collocated dyads appear to update their perceptions of trustworthiness based on their perceptions of their team members' performance. We conclude that the context in which people are working may have a significant impact on the way that trust is developed.

Introduction

With the help of Internet technologies, such as email and computer-based collaboration tools, the number of geographically distributed, cross-functional teams (Parker, 1994), the number of sites at which team members work (Armstrong & Cole, 2002) and the interdependence of the tasks undertaking by distributed teams are increasing. Globalization of organizations through mergers and growth makes distributed teams important for international coordination and valuable in tying together resources from different geographic regions (Carmel, 1999). Although remote workgroups have existed throughout history (see King & Frost, 2002), remote operations historically undertook more independent activities, such as the sourcing and transportation of goods (O'Leary, Orlikowski, & Yates, 2000). Today's distributed teams perform highly interdependent tasks such as creative design and problem solving. However, such strong interdependence requires trust (Shepard & Sherman, 1998; Shapiro, 1987).

In this chapter, we explore the relationship between geographic distribution and trust among distributed and collocated members of global teams. We examine the development of trust between members of these teams as well as the effect of trust on individual performance.

Trust has been defined as "a psychological state comprising the intention to accept vulnerability based on positive expectations of the intentions or behavior of another" (Rouseeau, Sitkin, Burt, & Camerer 1998: p. 395; see also Mayer, Davis & Schoorman, 1995). However, trust is only meaningful within a particular context or situation (see Gambetta, 1988). Hardin (2000) offers the trust equation, "A trusts B about X." The trustor, person A, trusts the trustee, person B, about X, the object of trust, which

is the task or behavior that the trustor expects. We add "Z" to the equation to create "A trusts B about X when Z", where Z is the context of trust or the situation in which the trustor and trustee are embedded. We believe that examining the object and context of trust are particularly important in the work environment where trust may be narrowly construed to encompass performance of a particular task and one's ability to act may be largely determined by the characteristics of the context in which one works.

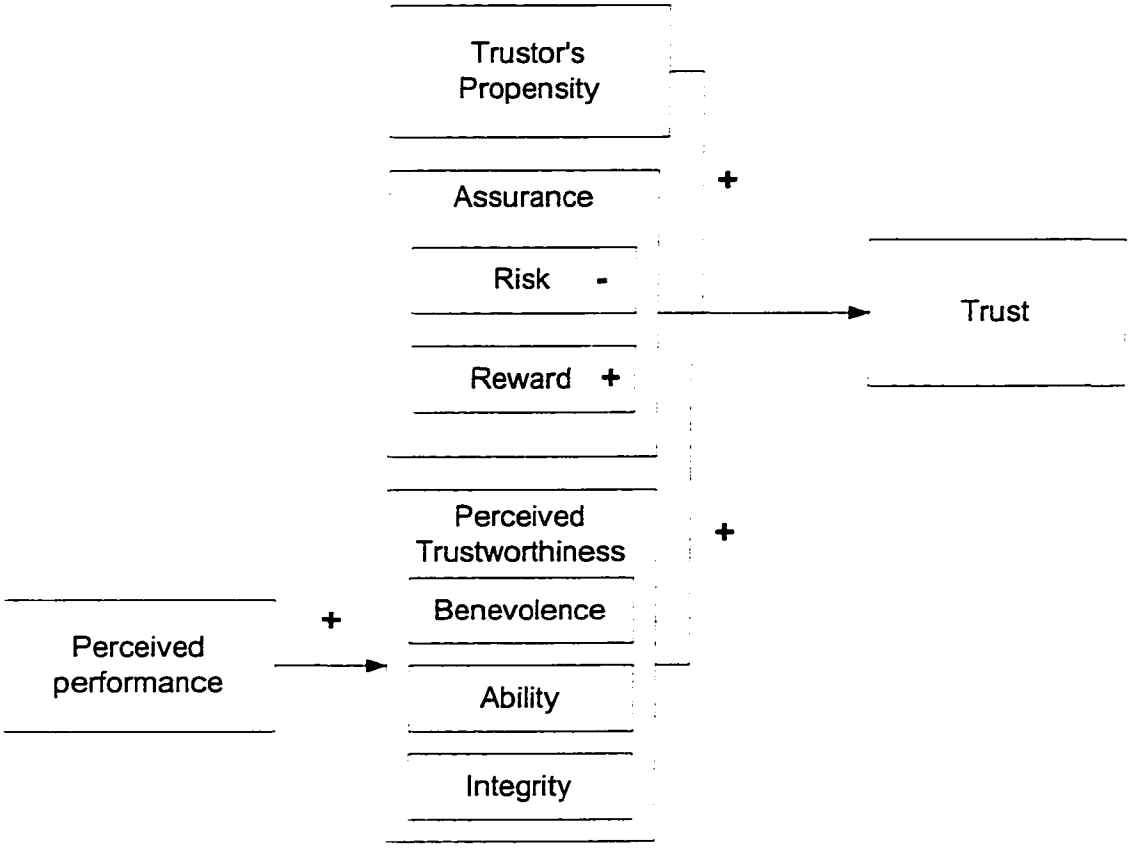
Trust Development

In their model of organizational trust, Mayer, Davis, and Schoorman (1995) argue that trust develops based on the trustor's propensity to trust, the extent to which the trustee perceives the trustor as trustworthy, and the trustor's perception of situational risk. They argue that perceived trustworthiness is a function of how capable (ability), how benevolent (caring), and how honorable (integrity) the trustor perceives the trustee to be. They add that risk will moderate the relationship between the trustor's attitude and their willingness to act in a trusting way such that higher levels of trust will be required when higher levels of risk are present. Zolin and colleagues (Zolin, Hinds, Fruchter, and Levitt, 2001) add several components to the Mayer, Davis, and Schoorman (1995) model. They argue that the trustor's assessment of the rewards possible from the situation also come into play in determining the trustor's behavior suggesting that "assurance," which combines risk and reward, more completely captures the situational determinants of trust. Yamagishi and Yamagishi (1994: p. 129) define assurance as "a perception of the incentive that leads the interaction partner to act cooperatively". We argue that assurance is a combination of both risk and reward such that lower levels of risk and higher levels

of reward increase the extent to which the trustor can expect to receive value from the interaction and trust a team member.

Mayer et al also add the trustor's perception of the trustee's performance, arguing that perceived trustworthiness will be updated based on the extent to which trustees are perceived as following through on commitments. The resulting model of trust development is presented in Figure 3.1.

Figure 3.1. Model of Trust Development



The model of trust development presented above, however, may not obtain for all situations. In particular, we consider the situation in which team members are geographically distant from one another and must rely more heavily on technology to mediate their interaction. In these situations, trust may be particularly important because

monitoring is more difficult. Ironically, trust also may be more difficult to develop because team members have fewer opportunities to interact face-to-face, have less unplanned interaction, rely more heavily on technology to mediate their interactions, and often are more heterogeneous because they inhabit different cultural contexts.

Trust in Geographically Distributed Teams

The trend toward distributed teams is growing (Armstrong & Cole, 2002). In a recent study, respondent firms reported that 63% of their new product development teams would be geographically distributed within the next few years, with 22% globally distributed (McDonough, Kahn, & Barczak, 2001). Nine percent of the firms responding indicated that they expected to rely exclusively on geographically distributed teams. Although distributed teams are becoming increasingly prevalent, little is known about the social dynamics that result for team members (see Maznevski & Chudoba, 2000) or the extent to which our current understanding of team dynamics will apply (Hinds & Bailey, 2000). For the purposes of this paper, we define a geographically distributed team as one in which some team members are located in different cities or countries and geographically distributed dyads as dyads in which the team members are located in two different cities or countries.

Working on a geographically distributed team means that team members spend less time in the presence of others, often have different physical and cultural contexts, and rely more heavily on technology to mediate their interactions – technologies such as telephone, video and teleconferencing, Internet chat, and facsimile. Because members of distributed teams generally spend less time in the presence of one another, they are less likely to develop rapport and trust (Kiesler & Cummings, 2002). With distance,

spontaneous interaction is more difficult thus reducing information sharing and interpersonal attraction between members (Kiesler & Cummings, 2002). Simply being co-present with others also increases feelings of familiarity (Zajonc, 1968), which has been linked to the development of trust on work teams (Wilson, 2001).

In addition to reduced physical proximity, distributed team members often inhabit different physical, organizational, and cultural contexts. Members in different locations may use different technologies, have different work processes, conform to different interaction norms, be paid based on different reward and compensation systems, have different vacation schedules, confront different stressors (i.e., economic or political issues), and have different cultural perspectives (e.g., see Armstrong & Cole, 2002). For example, Armstrong and Cole (2002) describe a situation in which "...the two sites had different definitions of completed product quality and tested their work with different procedures. These differences caused unexpected conflicts and delays and were taken by either side as signs of bad faith and political maneuvering" (p. 200). In addition to creating or fueling conflict, occupying different contexts can detract from mutual understanding (Clark & Brennan, 1996; Fussell & Kreuz, 1992; Olson & Olson, 2000). Cramton (2001) describes five problems that result from differences in context; 1) failure to communicate contextual information, 2) unevenly distributed information, 3) differences in speed of access to information, 4) difficulty in communicating and understanding the salience of information, and 5) difficulty in interpreting the meaning of silence. Because the development of trust is, in part, based upon information about the trustee and the situation, reduced or inaccurate information about the trustee is likely to negatively affect the development of trust. Burt and Knez (1996) also offer evidence that

the probability of trust will increase with indirect connections that are likely to provide gossip and rumor. When embedded in different social contexts, indirect connections are less prevalent and thus, trust may be inhibited.

Members of distributed teams also must rely more heavily on technology to mediate their interaction. Reliance on communication technologies has been associated with less social interaction (Sproull & Kiesler, 1991; see also Olson & Olson, 2000), more time pressure, less information sharing (Hollingshead, 1996), more misunderstandings (Armstrong & Cole, 2002; Cramton, 2001), and more conflict (Mannix, Griffith, & Neale, 2002). Communication technologies, in comparison to face-to-face interaction, do not offer as many of the social cues (touch, gestures, voice-intonation, facial expressions, etc.) that are helpful for interpreting feedback and negotiating understanding.

We believe that gathering the information required to assess the extent to which someone is a caring and honorable person, and to assess their competence vis a vis the task that must be accomplished will be difficult when distant, in a different context, and reliant upon technologies for interaction. Because the development of trust is based largely upon information that the trustor has about the trustee and the situation, such a reduction in information is likely to inhibit the development of trust. For example, Grinter, Herbsleb and Perry (1999: 312) reported that team members on distributed teams had more difficulty assessing the competence of others – they did not trust that those at remote sites could "handle the work assigned to them." We propose that

H1: Trust will be lower in distributed dyads than in collocated dyads.

There is evidence that trust changes over time as people gather more information and update their perceptions (Kramer, 1999; Rousseau et al, 1998; Lewicki & Bunker, 1996). In our model (Figure 3.1), we assume that trust will be updated as team members observe the performance of their colleagues and evaluate the extent to which they followed through on commitments. However, individuals rarely seek disconfirming information and may actually try to avoid it (Good, 2000). Therefore, trust may be resistant to change once established and thus more stable over time than predicted (see Ring & Van de Ven, 1994). This may be particularly true on distributed teams because disconfirming information may be less visible (see Cramton, 2002). Thus, members of these teams may be able to avoid disconfirming information and sustain their initial (and perhaps inaccurate) impressions for an extended period of time. This is consistent with the findings of Jarvenpaa and Leidner (1999) that distributed teams that establish trust from the beginning are more likely to sustain high levels of trust.

We do, however, expect some development of trust over time in distributed teams. Although distance and reliance on mediating technologies may prove challenging, there is evidence that teams adapt to media (e.g. Markus, 1994; Orlikowski, 2000; Zack & McKenney, 1995) and develop close inter-personal relationships over time (Walther, 1997). We posit that

H2: Members of distributed teams will modify their trust of one another over time, but less so than will members of collocated teams.

In their model, Mayer, Davis, and Schoorman (1995) propose that risk will moderate the relationship between trust and trust behavior. Zolin et al. (2001) extend and modify this aspect of Mayer and colleague's model by adding perceived reward – the

extent to which the trustor stands to benefit from the interaction. For example, if the task has the potential to result in great value and reliance on the trustee is the best way to attain that value, then the potential reward is great.

Normally, one would suppose that high levels of risk would make trust more difficult whereas generous rewards would motivate team members to trust one another so that the reward could be achieved. However, in geographically distributed teams, we posit that risk will loom larger and may suppress the development of trust. We expect this effect for two reasons. First, we anticipate that team members will experience work with distributed team members as inherently more risky. Regardless of the reality of the situation, people enjoy distributed work less and report that they find success more elusive in distributed situations (e.g. McDonough, Kahn, & Barczak, 2001). Thus, additional situational risk may prove intolerable. Second, we anticipate that members of distributed teams will have more difficulty managing the risks inherent in the situation. For example, additional risk is incurred when teams work with an uncertain, untested technology. When distributed, it may be even more difficult to develop a common understanding of the new technology and manage this risk as team members proceed with different perceptions of how the technology works and should be harnessed for the project.

H3: In distributed dyads, team members' trust will be predicted by perceived risk more so than in collocated dyads.

Trust and Performance

Trust between team members can have a positive effect on performance (see Hughes, Rosenbach, & Clover, 1983; Klimoski & Karol, 1976), although this effect may

be moderated by motivation (Dirks, 1999). In geographically distributed settings, we expect the trust-performance relationship to be even stronger. As discussed earlier, distributed teams have more opportunities for miscommunications and misinterpretations. They also have less opportunity to talk through issues, gain clarification, and resolve misunderstandings. Thus, members of distributed teams may be called upon more frequently to give other team members "the benefit of the doubt" when the others' actions are not visible and are subject to misinterpretation. Distributed team members may need to rely on trust to avoid a downward cycle of blame and faulty attributions, which may result in withholding of information, competition between group members, and an unwillingness to coordinate work together. In a recent study of firms with new product development teams, behavioral challenges were reported to have a significant effect on the performance of distributed teams and "generating trust between team members" was seen as one of the top three behavioral challenges for these teams (McDonough et al, 2001). Thus, we predict that trust will have a greater impact on performance in distributed as compared with collocated dyads.

H4: Trust will be more important to performance in distributed dyads as compared with collocated dyads.

Method

To evaluate the development of trust in geographically distributed dyads, we studied student construction design teams that each included an architect, a structural engineer, and a construction manager. Students, on average, reported 8 months of full-time work experience in their field and 12 academic courses in the relevant disciplines.

We observed the teams over three consecutive years and present survey data collected the last year.

Over a period of three years, we used student teams to develop and modify a model of inter-personal trust in geographically distributed, cross-functional teams. Student teams were chosen for three main reasons. First, student teams replicate a work environment more closely than participants in other forms of research methodology, such as a synthetic laboratory experiment. Second, compared with industry teams, student teams can be studied more closely using surveys and interviews. Student teams provide higher response rates to questionnaires and accede to the more frequent surveys required for longitudinal studies. Third, student teams all start at the same time, work on the same task and operate in the same organizational environment. This greatly reduces the number of variables that must be measured by holding constant these factors.

A number of issues make the study of trust in a working environment complex, and can make the development and testing of a model problematic. First is the dynamic nature of trust. Trust builds over time and, thus, there is a need for longitudinal studies of trust. Second, trust is a social psychological construct that is experienced across many levels of social structure. In our natural language use of the word trust, we speak not only of trusting an individual, but also of team trust, organizational trust, industry trust, trust in society and trust in government. Somehow, some or all of these factors interact to influence an individual, in the design and execution of his or her behavior. In this study, we chose to study trust at the inter-personal level, rather than at the team or organizational levels. Trust as an attitude or a behavior operates at the individual level

and influences individual behavior. Studying inter-personal trust keeps the analysis on the individual level, rather than spanning levels as described by Coleman (1990).

Participants

As described in Zolin et al. (2001),

> The participants for this study were students in the seventh and eighth generation of a Computer Integrated Architecture-Engineering-Construction (A/E/C) class organized by a West Coast University in the United States (Fruchter, 1999). Masters students drawn from United States, European and Asian universities in three disciplines—architecture (A), engineering (E), and construction management (C)—worked in globally distributed teams for four months to design a five-million dollar building according to a client's specifications. The graduate students were assisted by undergraduate 'apprentices' and mentored by globally distributed professionals working in each discipline.
>
> To facilitate assignment to groups, students were randomly assigned a skill profile during an initial face-to-face meeting attended by all students. Each project had specific requirements, such as being located in an earthquake zone. In an icebreaking exercise, students identified and joined the project that best suited their assigned skill profile (e.g., those with experience working in earthquake zones were likely to join projects with a building to be located in an earthquake zone). Each team included at least one member who was not collocated. After the two-day project launch, teams did not meet again face-to-face until the final presentation four months later. Distributed team members communicated mainly through computer-based Internet applications. Internet meeting applications

> allowed audio and video communication and desktop file sharing. Internet message applications allowed synchronous message transfer between two or more parties. An Internet application developed for the course facilitated the posting and retrieval of messages and files. Collocated team members used face-to-face meetings as needed. (p. 12)

Data Collection

We provided online surveys and "conducted structured interviews with 12 teams composed of three to four team members each, distributed among 10 locations in six countries - the United States, Switzerland, Holland, Germany, Slovenia, and Japan" (Zolin et al., 2001: 13). All team members participated in the research. A survey during the first week of the project contained questions about the number of courses taken, work experience in each discipline, and the students' perceptions of their own risks and rewards associated with the project. Approximately one month later and three months later, we distributed dyadic surveys in which we asked each team member to rate each of his or her other team members on trustworthiness (care, ability, and integrity), perceived performance and to indicate the extent to which they checked on the work of each other team member (our measure of trust). This survey yielded 108 usable dyadic responses (e.g., responses from A about B). The interviews, which were recorded and the interviewer's notes transcribed, were used to enrich our understanding of what transpired in these teams.

Measures

Dependent Variables. Our primary dependent variables of interest are trust and performance. Zolin et al. (2001) describe a measure that taps into the behavioral aspects

of trust – monitoring or checking on the work of the trustee. This measure is consistent with the argument that in investigating trust, one must take into account the situation, thus A trusts B about X (see Hardin, 2000). To create a measure of checking, we averaged across four items from the dyadic survey (see figure 3.2). The scale reliability for the four items was high (alpha=.77). Each item was rated on a 5-point scale with 5 equating to high levels of checking. By reverse coding our checking variable, we created a measure of trust.

To create a measure of performance, we used the student's final grade. A portion of the grade was determined based on the student's contribution to the project in their own disciplinary area (e.g., architecture, engineering, or construction management), which they presented at the end of the project. Another significant portion of the grade was based on the overall team project. A multi-disciplinary team of faculty and industry experts assessed the individual and team presentations. Thus, we considered the grade to be a reasonable measure of the team member's performance on the project.

Figure 3.2. Survey items. (* These items were reverse coded)

Trust Behavior – Checking
1. How often have you needed to check/ask to see if this team member had completed her/his commitments?
2. How often have you counted or compared to see if this team member was contributing to the group?
3. How often have you worried about this team member's performance?
4. How often have you checked on this team member's progress on the deliverables promised?

Propensity (General trust)
1. Most people are basically good and kind
2. Most people are trustworthy
3. Most people are basically honest.
4. I am trustful.
5. Most people are trustful of others.
6. Most people will respond in kind when they are trusted by others.
7. People are always interested only in their own welfare.*
8. No matter what they say, most people inwardly dislike putting themselves out to help others.*
9. One can avoid falling into trouble by assuming that all people have a vicious streak.*
10. In this society, one does not need to be constantly afraid of being cheated.*
11. People usually do not trust others as much as they say they do.*
12. In this society, one has to be alert or someone is likely to take advantage of you.*

Risk (Year 1)
Do you feel that you are at risk if your team mates do not perform?
What is at stake for you if your team mates do not do their job?
What would happen if a team mate just refused to perform?

Reward (Year 1)
1. What reasons did you have for taking on the project?
2. How important were those reasons?

Risk (Year 2)
1. To what extent do you feel at risk if one team member does not perform?
2. How much is at stake for you (what do you have to loose) if one team member does not do their job?
3. How serious will it be if one team member refuses to perform through most of the project?

Reward (Year 2)
What goals do you do you hope to achieve with this project? (Not directly used)
2. How important are those goals?

Perceived Trustworthiness: Benevolence
1. How often has this team member made an extra effort to make your job easier?
2. How often has this team member listened carefully to hear your problems or concerns?
3. How often has this team member notified you when she could not meet a commitment?
4. How often has this team member passed on new information or ideas that may be helpful to you or the group?
5. How often does this team member check to make sure that communication was received or understood?

Ability
1. How often has this team member exhibited technical or project competence?
2. How often have you noticed that team member exhibit professional behavior?

Integrity
1. To what extent is this team member Honest/Dishonest?*
2. To what extent is this team member Virtuous/Sinful?*

Perceived performance
1. How often did this team member follow-through on work commitments?
2. How often did this team member complete work commitments on time?
3. How often did this team member fail to follow-through on work commitments? *
4. How often did this team member fail to complete work commitments on time? *

Independent Variables. The primary independent variables of interest in this study are geographic distribution, perceived trustworthiness (care, ability, and integrity), trustor risk and reward, and perceived performance.

Geographic distribution is a dichotomous variable in which dyads are either located on the same campus (collocated = 0) or split between two distant campuses (distributed = 1). Distributed dyads could be as close together as 50 miles or as far apart as different continents. We examined the effect of time zone, but saw little difference, so collapsed distribution into a single dichotomous variable.

Perceived trustworthiness was measured by the care, ability, and integrity reported by the trustor about the trustee in the dyadic surveys. Each of the items (see figure 3.2) was measured on a 5-point scale with 5 equal to higher levels of care, ability, or integrity. Care, ability, and integrity were summed and divided by 3 to create a scale of perceived trustworthiness with 5 equal to high and 1 equal to low perceived trustworthiness.

Perceived risk and reward were assessed from questions included in our demographic survey (see figure 3.2) so that we could assess perceptions of risk and reward as early in the project as possible. The scale for these items was 1 to 3 where 3 was equal to high levels of risk or reward.

Perceived performance was a measure of the trustor's perception of the extent to which the trustee followed-through on commitments and delivered work on schedule (see figure 3.2). We used a 4-item scale (scale reliability = .87) with each of the items measured on a 5-point scale with 5 equivalent to high levels of perceived performance. To create a measure of perceived performance, we averaged across the 4 items.

Measures for perceived trustworthiness and perceived performance were taken from the dyadic surveys.

Analysis

We tested our hypotheses using linear regression models and structural equation modeling. Because our data were dyadic, we were concerned about autocorrelation between the trust reported by members of the same dyad (e.g. reciprocal trust). However, the Durbon-Watson (Hamilton, 1992) test statistic was higher than the upper limit (d=2.14) suggesting that reciprocation of trust was not strong in the dyads we studied.

We conducted structural equation modeling using the estimation procedure of AMOS (Hoyle, 1995; Byrne, 2001) to observe the effects of variables over time. Our goal was to test our hypotheses about trust development in distributed dyads as compared with collocated dyads. Hence, we adopted a strictly comparative analysis approach. We also used Bollen-Stine bootstrapping to adjust for the small sample size and non-normal distributions of variables (which can overestimate the χ^2 statistic and lead to rejection of acceptable models) thus improving our ability to assess model fit (Byrne, 2001).

Results

We collected data at three points in time to enable us to conduct longitudinal analyses, examining trust development over time. The descriptive statistics for and correlations between our variables are provided in Table 3.1. On the whole, participants reported a moderate level of checking with the average being 2.51 (SD = .88) on a 5-point scale at month one and 2.42 (SD=.70) at month three. As expected, the correlation between checking at month one and checking at month three (r=.32, p<.001) was positive and significant suggesting that initial trust predicted later trust. Perceived

trustworthiness at month one also predicted checking at month three ($r=-.44$, $p<.001$) indicating that perceived trustworthiness may have contributed to later trust.

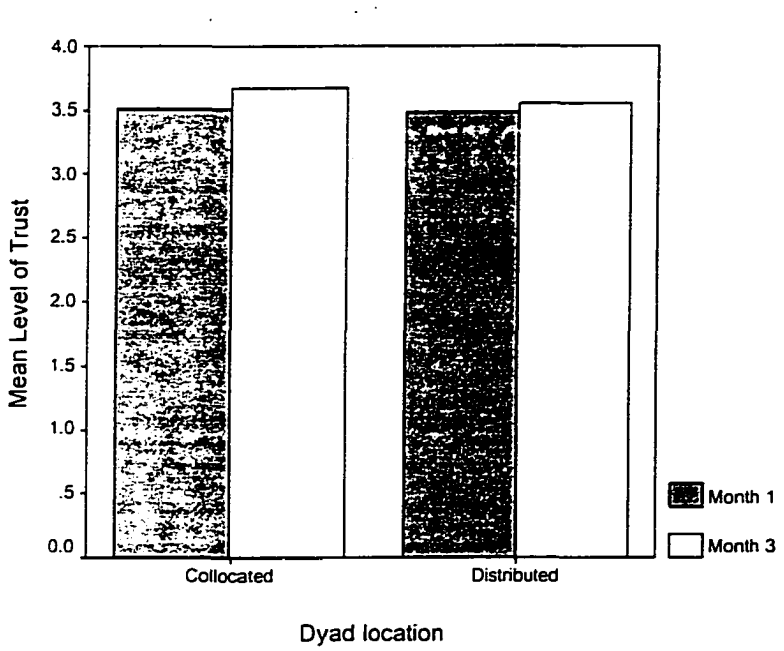
Table 3.1. Descriptive Statistics and Correlations for Variables. (N= 108).

Variable	Mean	Std Dev.	1.	2.	3.	4.	5.	6.	7.	8.
1. Checking (month 1)	2.51	.87	1.00							
2. Checking (month 3)	2.42	.70	.32***	1.00						
3. Trustor's performance	3.80	.46	.07	-.03	1.00					
4. Distribution	.71	.45	.02	.08	-.11	1.00				
5. Perceived trustworthiness	3.58	.75	-.22*	-.44***	-.12	-.14	1.00			
6. Trustor risk	2.10	.43	.17+	.30**	-.13	.06	-.16+	1.00		
7. Trustor reward	2.47	.55	-.11	-.18*	-.17+	.21*	.06	.03	1.00	
8. Perceived performance	3.94	.82	-.47***	-.43***	-.01	-.12	.58***	-.20*	.25**	1.00
9. Courses	11.49	5.40	.22*	-.15	.18+	-.05	.26**	-.12	-.14	.10

+ p < .10 * p < .05, ** p < .01, *** p < .001

In hypothesis 1, we argued that trustors in distributed dyads as compared with those in collocated dyads would trust their team members less. We therefore expected a negative relationship between geographic distribution and trust. We compared the mean level of trust by distributed and collocated dyads in month one and month three (see Figure 3.3). In an ANOVA analysis, comparing distributed and collocated dyads, we found no significant difference at month one ($F[1, 106] = 0.04$, $p<.85$) or at month three ($F[1, 106] = .69$, $p<.41$). These data provide no support for hypothesis 1, instead suggesting that distributed and collocated dyads experienced the same amount of trust.

Figure3. 3. Comparisons of mean levels of trust for distributed and collocated dyads for months 1 and 3. (N = 108).



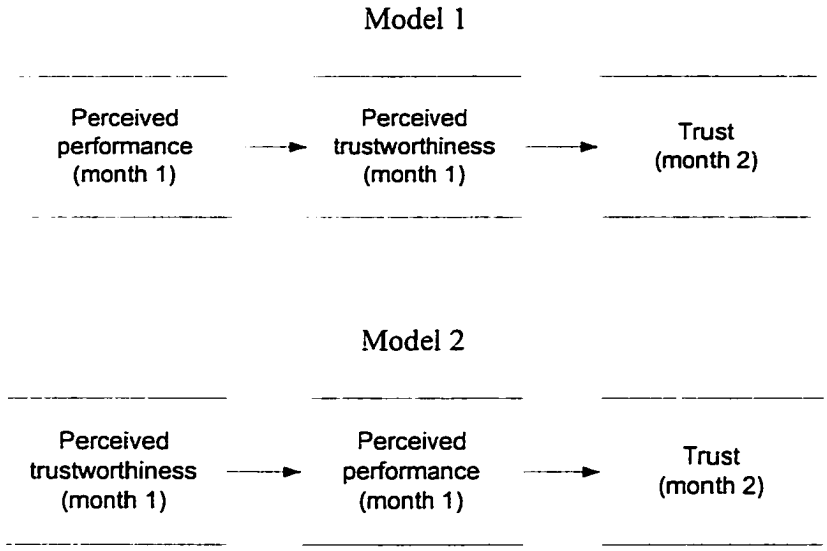
We also argued (H2) that distributed dyads would update their trust less over time than would collocated dyads. A quick look at Figure 3.3 indicates that members of collocated dyads did not change their level of trust from month one to month three any more than did those in distributed dyads. A one-way ANOVA confirms no significant

difference between distributed and collocated dyads in the change in trust between month one and month three ($F[1,106] = .20$, $p < .66$). However, these analyses merely suggest that average levels of trust did not change. It is possible that trust changed more in collocated teams, but that the averages obscure increases and decreases in trust. We therefore examined more closely the changes in trust. An examination of absolute difference in trust between month one and month three indicates that distributed dyads exhibited significantly less change than did collocated dyads ($F[1,107]=4.09$, $p<.05$). Over 19% of the collocated dyads decreased the extent to which they checked on their team members (suggesting increased trust) whereas only 9% of distributed dyads decreased checking from month one to month three. Further, over 16% of the collocated dyads increased the extent to which they checked on their team members (suggesting reduced trust) whereas only 10% of distributed dyads increased checking from month one to month three. These analyses provide some support for hypothesis 2, indicating that trust may increase more, but that it also may deteriorate more in collocated than in distributed teams.

In our logic leading up to hypothesis 2, we argued that participants would use performance information – perceived performance – to update their trust in their team members. To the extent that team members delivered on commitments, trust should increase. To the extent that team members did not deliver on commitments, trust should decrease. However, we expected this effect to be stronger in collocated teams because they are able to more easily gather performance data. To investigate this, we created a structural equation model (AMOS) that reflected the predicted relationship (see model 1, figure 3.4*Figure 3.4*). In model 1, perceived performance is used to predict perceived

trustworthiness. When using the data from collocated dyads, this model fit reasonably well (χ^2 [1, N = 31] = .23, p<.90). However, when testing the same model with data from the distributed dyads, the model fit poorly (χ^2 [1, N = 77] = 8.92, p<.003), providing additional support for our arguments that distributed teams would use performance data less to update their perceptions than would collocated teams. In fact, a better fit with the data from distributed dyads is a model (see model 2, Figure 3.4) in which perceived performance mediates the relationship between perceived trustworthiness at month one and trust at month three (χ^2 [1, N = 77] = .3.30, p<.07). To determine model fit, we used several standard fit indexes to compare model 1 with model 2. Byrne (2001) reports that a value above .95 in the RFI index indicates superior fit. The RFI of model 1 for distributed dyads is below .95 (.931) whereas the RFI of model 2 is above .95 (.974), indicating that model 2 has a more acceptable fit than model 1 for our sample of distributed dyads.

Figure 3.4. Structural Equation Models 1 and 2.

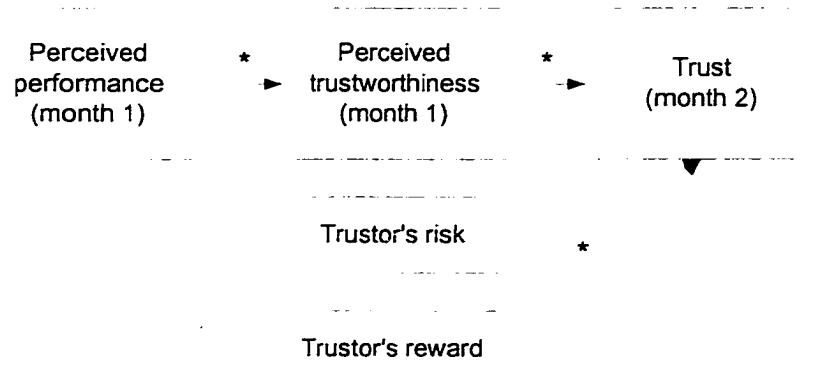


In our third hypotheses, we argued that team members in distributed dyads would use risk as a basis of trust more so than those in collocated dyads. Because model 1 fit better for collocated dyads, we added risk and reward to model 1 and used it to estimate for collocated dyads (see model 3, Figure 3.5). Similarly, we added risk and reward to model 2 and used it for the distributed dyads (see model 4, see Figure 3.5). Model 3 had a reasonable level of fit for the collocated dyads (χ^2 [6, N = 31] = 4.89, p<.56) Bootstrapping indicated a higher probability of fit (p < .61). However, model 4 did not fit as well for the distributed dyads (χ^2 [6, N = 77] = 14.24.65, p<.03), (with bootstrapping p < .10) although all of the relationships were significant except the relationship between reward and trust (β=.05, p<.62). As predicted, risk was significant in predicting trust for distributed dyads (β=-.22, p < .05), but not so for collocated dyads (β=-.25, p < .11). Consistent with hypothesis 3, these analyses indicate that high levels of

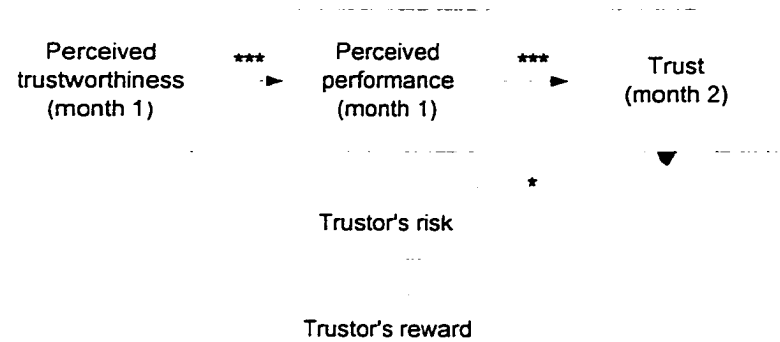
perceived risk may have had a more detrimental effect on trust in distributed as compared with collocated dyads. However, contrary to our expectations, distributed dyads did not report higher levels of perceived risk than their collocated colleagues ($F[1,106]= .32$, $p<.57$).

Figure 3.5. Structural Equation Models 3 and 4.

Model 3 (Collocated Dyads)



Model 4 (Distributed Dyads)



* p < .05, ** p < .01, *** p < .001

We also argued that trust would be more important to individual performance in distributed dyads (H4). To evaluate this hypothesis, we conducted OLS regression (see Table 3.2). In model A, we include the set of control variables that we expected might have a direct effect on performance. We included the number of relevant courses (the sum of courses that participants had taken in architecture, structural engineering, and construction management) with the expectation that students who had completed more relevant coursework would perform better. We also added risk, reward, and the interaction between risk and reward to the model with the assumption that perceived risk would indicate the perceived difficulty of the project and reward would be a proxy for motivation. That is, if the reward is perceived to be high, then the participant may be more motivated to perform well. The relationship between risk and reward was expected to affect motivation as well – to the extent that risk was perceived as low[1] and reward was high, then motivation should have been high and better performance should have resulted. From model A, none of the control variables were significant although risk (reverse scored) was suggestive ($\beta = .61$, $p < .07$) indicating that lower levels of perceived risk may lead to more successful performance.

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[1] If participants perceived this course as having no challenge, then that could also have a negative effect on motivation. However, the quality of work expected in this course is generally considered quite challenging and we assume that all students were at least somewhat challenged by the project.

Table 3.2. OLS estimation of trustor's performance (N=104).

	Model A	Model B	Model C	Model D	Model E
Intercept	**	**	**	**	**
Number of relevant courses	.15	.15	.17 +	.14	.18
Geographic distribution[a]	-.07	-.07	-.76	-.07	-.09
Risk (reverse scored)	.61 +	.61 +	.63 +	.61 +	.64 +
Reward	.48	.48	.53	.48	.53
Risk (reverse) X Reward	-.78	-.77	-.83	-.78	-.85 +
Trust (month 3)		-.01	-.23		
Distribution X Trust			.71		
Increase in trust				.01	-.15
Distribution X Increase in trust					.22 +
Adj. R-squared	.05	.04	.05	.04	.06
Model F	2.06 +	1.60	1.71	1.70	1.88 +
Degrees of freedom	5, 99	6,98	7,97	6.96	7,97

[a] Geographic distribution was coded as 0, 1 where 1=distributed and 0=collocated.

[b] Checking at month 1 minus checking at month 3.

+ p <.10 * p < .05 ** p < .01 *** p < .001

In model B, we add trust to the model. We used trust (the reverse score of checking) rather than checking in these models so that the interaction terms were more interpretable. However, we found no significant relationship between trust and

performance (β = -.01 , p<.93). Although the interaction between distribution and trust when predicting performance was in the expected direction (β = .71 , p <.20) – with an increase in trust in distributed dyads having a positive effect on performance – the results were not significant. We then replaced trust with increase in trust from month one to month three with the expectation that building trust over time would improve performance, particularly in geographically distributed teams. Surprisingly, we found a negative (but non-significant) relationship between increase in trust and performance although the interaction between distribution and an increase in trust was in the expected direction (β = .22 , p <.10). These results provide only weak support for the idea that trust will be more important to performance on distributed as compared with collocated teams.

In the previous analyses, we predicted the performance of the trustor with the assumption that the extent to which the trustor is able to trust his/her team members will influence his/her ability to perform well. We also reason that the extent to which someone is trusted may affect his/her performance. However, in analyses similar to those reported above, we found no evidence that trust predicted trustee performance on these teams.

Discussion

In this chapter, we examined the affect of geographic distribution on the development of trust. Although we expected to find less trust between team members who were geographically distant, we found no evidence of this. We did, however, find that trust was more stable and may develop differently in geographically distributed dyads. In collocated dyads, trust was more volatile – both increasing and decreasing more

over time than in distributed dyads. We also found that although collocated team members updated trust based on their perceptions of their team members' performance on commitments, distributed team members appeared to use their initial perceptions of trustworthiness to evaluate performance. These data suggest that first impressions are particularly powerful and enduring on geographically distributed teams.

Our data also provide some support for the argument that distributed teams will invoke "swift trust"– trust that is conferred based on the role the trustee occupies (Meyerson, Weick & Kramer, 1996; Jarvenpaa & Leidner, 1999). "Swift trust" can provide the basis for impersonal trust when trust is necessary and there is not adequate time to develop it. Jarvenpaa and Leidner (1999) reported that some distributed teams they studied developed "swift trust" – establishing trust early on and maintaining it throughout a 6-week project – but that others had difficulty developing trust if it was not established from the beginning. Our results also indicate that trust in distributed teams was relatively stable over time. If it started out high, then it tended to remain high throughout the project. These findings suggest that trust may be difficult to develop in distributed teams, but that "swift trust" may be a desirable alternative.

It is, however, important to consider that the teams in our sample met at the beginning of the project for at least two days of icebreaking exercises and project planning. This allowed the partners in distributed dyads to form rich first impressions of each other. Many distributed team members do not have this opportunity and, in fact, may never meet face-to-face. We believe that team members who do not meet face-to-face early in the project will not establish such high levels of trust and may not be able to maintain high levels of trust over an extended project. Therefore, it is important that

future research examine the development of trust in distributed teams that do not have the opportunity to meet face-to-face or meet for the first time later in the project.

It is also important to note that trust *did* change over time in distributed dyads even though it did not change as much as it did in collocated dyads. There is ample evidence that distributed team members adapt to distance and to the technologies they are required to use (e.g. Zack & McKenney, 1995) and learn to develop strong inter-personal relationships with distant colleagues (see Walther, 1997). Distributed team members in our sample increased trust (9%) as nearly much as they decreased it (10%) although collocated team members increase trust (19%) more than they decreased it (16%). These data suggest that trust may be more difficult to create and may deteriorate more at a distance, but more research is needed to evaluate this claim.

We also found that trust between members of distributed dyads is more susceptible to perceptions of risk. Distributed team members who perceived the situational risk to be high were less inclined to trust their distant colleagues, checking more frequently on their behavior. We predicted this effect based on the argument that managing risk would be more difficult in distributed situations because managing risk calls for more information sharing and more negotiation, which are difficult on distributed teams. However, in risky situations, too much trust may be detrimental to performance. Our inverse measure of trust – checking – suggests that distributed team members who perceived the situation to be risky checked more frequently on the work of their distant team members. In these situations, checking may be beneficial as checking may spur information sharing and avoid the potential for miscommunications. However, in our evaluations of performance, we have no evidence that trust is more or less

important on distributed as compared with collocated teams. We did, however, find that increasing trust might be more important in distributed than in collocated teams. We speculate that this may be the result of increased cooperation and information sharing between team members. Unfortunately, we do not have the data to evaluate this proposition, but hope that future research will more deeply explore the complex relationship between trust and performance in distributed teams.

As predicted in the model, collocated team members used their evaluation of performance as information upon which to update perceived trustworthiness. In contrast, distributed team members used their assessment of perceived trustworthiness to evaluate performance. In addition to affecting the development of trust in distributed teams, this could have implications for the ability of distributed team members to accurately assess the quality of work produced by other team members. However, in regression analyses, perceived performance predicted performance better in distributed (β=.25, p<.03) than in collocated dyads (β=-.09, p<.65) suggesting that the information used to update impressions of collocated team members may not have been sound. It is possible that distributed team members are less biased by factors (e.g. attractiveness, friendliness, ethnicity, etc.) unrelated to performance than are collocated team members. Closer examination of the relationship between inter-personal impressions and performance in distributed teams seems a fruitful direction for future research.

There are several serious limitations to the study we presented here. First, all of the teams that we studied were distributed teams. Our comparisons were not between collocated and distributed teams, but between collocated and distributed members of distributed teams. Although, this is not necessarily an issue when examining inter-

personal trust, it does weaken our ability to generalize the results to collocated teams or to collocated dyads that are members of collocated teams. We believe it is important that future research compare the experience of members of collocated teams with the experience of members of distributed teams. The unit of analysis in this study was the dyad. Our sample of teams was small (n=12), so it was not possible to conduct analyses to understand the dynamics of team-level trust on distributed teams. We also believe that this is an important avenue for future research. Our sample of collocated dyads also was small. Such a small sample may have obscured differences that existed. Therefore, we caution the reader to look at the patterns that we uncovered and not at the differences we neglected to find.

Another limitation of this work is that it was conducted with student teams. Although this enabled us to examine teams that were similar on many dimensions, better isolate the factors in which we were interested, and conduct longitudinal research with a reasonably high response rate (and minimal turnover), we assume that trust and the development of trust between members of cross-functional, distributed teams in an industry setting are more complex than we were able to observe. With a better understanding of how trust may develop differently on distributed teams, we are armed to conduct future research in teams that are embedded in a more complex organizational environment.

Although we strove in this study to examine performance, our performance measure was not ideal. The grade was a single indicator and did not distinguish between timeliness, innovativeness, quality, and so forth, so we are unable to determine the extent to which trust differentially improved speed, innovativeness, and quality. Also, although

we have a measure of final project performance, we do not know the extent to which team members helped one another or contributed to the project in ways that did not accrue to their individual grade. To understand the relationship between trust, geographic distribution, and performance, it is important to conduct field studies that examine performance using multiple measures and multiple methods. We leave this for future research.

With the caveats above, we offer several recommendations for members and managers of distributed teams. First, it appears from this and other work that first impressions are particularly important for distributed teams. It therefore may be important that teams meet face-to-face early in the life of the team to get to know one another and discuss project goals (Armstrong & Cole, 2002; Kraut, Galegher, Fish, and Chalfonte, 1992). Our study also suggests that distributed teams may have difficulty observing each other's performance and gathering performance information. Facilitating the sharing of this information is an important role for leaders of distributed teams (see also Weisband, 2002). Finally, our examination of perceptions of risk suggests that perceived risk (if not risk itself) could be problematic for the development of trust on distributed teams. To the extent that risk or the perception of risk can be mitigated, distributed team members may be able to focus better on their own work and avoid the need to check frequently on the work of their distant team members. Alternatively, formal procedures (reports, meetings, and so forth) may alleviate the need to monitor the work of distant colleagues (see O'Leary et al, 2002). Early face-to-face meetings, sharing performance information between team members, and reducing perceived risk

might facilitate the development of trust on the geographically distributed teams that are proliferating in organizations.

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Chapter 4.

Realism and Control: Problem-based learning programs as a data source for work-related research*

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Abstract

Problem-based learning (PBL) is a pedagogical methodology that presents the learner with a problem to be solved to stimulate and situate learning. This paper presents key characteristics of a problem-based learning environment that determines its suitability as a data source for work-related research studies. To date, little has been written about the availability and validity of PBL environments as a data source and its suitability for work-related social science research.

We describe problem-based learning and use a research project case study to illustrate the challenges associated with industry work samples. We then describe the PBL course used in our research case study and use this example to illustrate the key attributes of problem-based learning environments and show how the chosen PBL environment met the work-related research requirements of the research case study.

We propose that the more realistic the PBL work context and work group composition, the better the PBL environment as a data source for a work-related research. The work context is more realistic when relevant and complex project-based problems are tackled in industry-like work conditions over longer time frames. Work group composition is more realistic when participants with industry-level education and experience enact specialized roles in different disciplines within a professional community.

Introduction

The goal of this paper is to present the key characteristics of a problem-based learning (PBL) environment that influence it's suitability as a data source for a work-related research study.

Problem statement

The use and diversity of PBL environments as a pedagogical methodology are increasing. The use of PBL environments as a data source for work-related research studies is also increasing.

Whereas the usage and diversity of PBL environments is increasing, little or no analysis has been done to determine how this data source compares to the use of other student or work place samples. This means that when considering a PBL data source for a research opportunity or when evaluating a PBL data source that has been used in a study, there are no guidelines to follow and a bewildering array of PBL options to consider.

Trust & PBL

We use a research study of trust in cross-functional, global teams to illustrate the challenges of using an industry data source. The Computer Integrated Architecture-Engineering-Construction (A/E/C PBL) course in Stanford University's Civil and Environmental Engineering Department (Fruchter, 1999) illustrates how a PBL environment can provide a useful alternative to industrial field studies or traditional kinds of synthetic experiments with students.

Based upon our case study, we identify the attributes of the PBL environment that affect the suitability of the PBL as a data source for work-related research studies.

Problem-based learning is a pedagogic methodology that presents the learner with a problem to be solved to situate the learning. The learner actively engages in framing the problem (Copland, 2000), identifying and gathering resources, and working with others to solve the problem.

Problem-based learning is sometimes called project-based learning; (Fruchter and Emery, 1999) when the problems are organized around a project, product-based learning (Cannon and Leifer, 2001) when the problem is focused on product design, team-based learning (Livingstone and Lynch, 2000) when the problem is worked upon by a group of students or even "problem, project, product, process, and people" based learning (Fruchter, 1999) when all these aspects are engaged.

Problem-based learning can be more similar to work-place learning than conventional University learning (Resnick, 1987). Work-place learning is more social than individual, uses the "tools of the trade" rather than pure mentation, involves contextualized reasoning rather than manipulation of symbols and results in specific learning rather than generalized learning (Resnick, 1987).

The use of problem-based learning is increasing in the education of students for professions engaged in the application of specialized skills and, simultaneously, as a research data source. Problem-based learning is being applied in the education and/or research of business managers (Iaocono and Weisband, 1997), teachers (MacDonald and Isaacs, 2001), principals (Bridges, 1992; Copland, 2000), geographical information systems designers (Livingstone and Lynch, 2000), mechanical engineers (Cannon and

Leifer, 2001), civil engineers and architects (Fruchter, 1999), medical and veterinary science practitioners (Garvin and Carrington, 1997).

There are many different problem-based learning courses, each with different characteristics that could impact upon the suitability of a PBL environment as a suitable research sample. This makes it difficult to assess a PBL environment as a potential data source for an experiment, or to assess the use of a PBL data source when evaluating an empirical research study.

In this paper, first we describe a research project that we use as a case study to illustrate the characteristics of PBL environments. Then we describe the potential data sources and analyze the PBL environment as a data source for a work related study. We discuss the advantages and disadvantages of using a PBL data source compared to an industry sample. The PBL data source chosen for our research project is then introduced and used to illustrate the key characteristics of a PBL environment as a data source for work-related studies. We then discuss the pedagogic advantages and limitations of using a PBL as a research data source. After our closing discussion of the contribution and limitations of this work we suggest future research.

The research study – "Trust In Cross-Functional, Global Teams"

Internet technology makes it feasible for firms to assemble and operate cross-functional, globally distributed teams. Although companies are rapidly adopting the model of cross-functional, global teams, little is known about the challenging new social environment that this creates for team members. One challenge may be the development of trust. Trust is necessary in cross-functional, global teams because team members must

depend upon each other to provide their specialized skills. At the same time, it may be difficult for interdependent team members to develop trust because of different disciplinary perspectives, regional or national cultures, and the lack of face-to-face interaction when working at a distance. Our research question was:

Which variables, when evaluated together, are the key predictors of trust in cross-functional global teams?

The goal of the research study was to test a model of inter-personal trust development (Zolin et al, 2001).

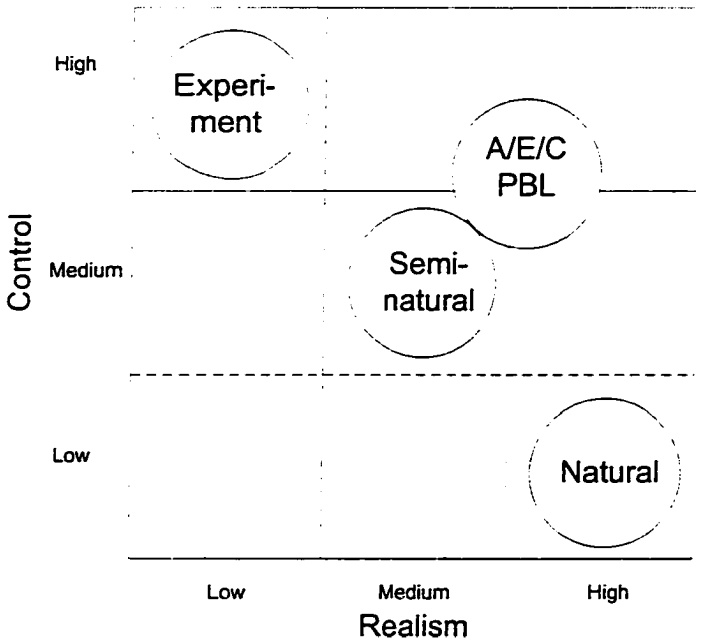
Our model of trust was based on six different theories of trust development. When those theories were integrated into the model, the variables that we used to predict trust were: the general disposition to trust of the trustor, the extent to which the trustor perceived risk and reward in the situation, and the perceived trustworthiness of the trustee. We also proposed that the more the trustor perceived that the trustee followed through in the past; the higher would be the trustor's perceived trustworthiness for the trustee in the future. We needed measures for these variables and we needed a measure for trust that took into consideration a key issue, the object of trust. Hardin says "A trusts B about X". Our measure of trust needed to be measured at the inter-personal level and take into consideration the nature of "X". At the time of starting our research project, there were no published scales to measure the variables we required. Therefore, we first had to develop an initial model with scales to operationalize the model variables. Then we had to test the scales. Finally, we had to test the model longitudinally to see if it correctly predicted changes in trust over time.

Data sources: Natural, semi-natural and artificial settings and artifacts

There are four different data sources from which a researcher can gather data for work-related studies: *natural social settings*, *semi-natural settings*, *artificial settings* and *artifacts* (Blaikie, 2000). Gathering data in a natural setting involves observing people as they go about their everyday lives, for example ethnographic techniques can be used to observe subjects at work. Gathering data in a semi-natural setting involves asking people to report on their activities, for example surveying workers. In an artificial setting, social activity is organized to simulate real life for experimental or learning purposes, for example inviting subjects to a sociological laboratory and asking them to behave as they would at work for a couple of hours. Artifacts also provide data, for example company records.

Experiments have the advantage of providing a means to isolate the key experimental variables (Babbie, 1998) through the creation of an artificial testing environment. In a classical experimental design, the sample is divided into the experimental group and the control group. The dependent variable is measured before the experimental stimulus is applied to the experimental group, but not the control group. The dependent variable is measured again afterwards, and the results of the experimental group are compared to those of the control group. The disadvantage of experiments is that, due to the fact that these are artificial tests, their relevance to the real world is always questionable (Babbie, 1998). Participants are aware that they are participating in an experiment and may not necessarily behave the same as they would in normal life. Thus, compared to natural and semi-natural settings, experiments are high on control but low on realism (See figure 4.1)

Figure 4.1. Control and realism of natural, semi-natural, experimental and PBL settings.



In contrast, in a natural setting the researcher observes the subjects as unobtrusively as possible. The researcher does not instigate events to represent the independent variable and variables are measured through observation rather than questioning. This option is high on realism but low on control because the events of interest may not occur naturally during the observation period. (See figure 4.1) When subjects are questioned in the semi-natural setting, control is higher than in a natural setting because the researchers can ask any questions they need to measure the variables of interest. Higher control is offset against reduced realism, because such questioning does not happen in a natural setting and the act of questioning can bias the subject's responses (Feldman & Lynch, 1988).

Analysis of PBL as a data source

This section considers the type of data source PBL represents in a work-related study, such as our research study of trust in global teamwork.

If the population of interest consists of students in PBL courses, then the study of those students using observational methods provides data gathered in a natural setting. The students were observed in the normal course of their day. If questionnaires or surveys are used, the data source is gathered in a semi-natural setting.

In contrast, if the population of interest is people at work, then the students in a PBL course represent a data source in an "artificial setting". The student's activities look like work, but they are structured for their educational benefit.

Because the PBL environment is an artificial setting, we have the advantages of greater control of the subject's environment, with the corresponding loss in realism. Nevertheless, compared to the traditional laboratory experiment, the PBL environment can provide a higher level of realism as we demonstrate using the case study.

Challenges in using work-related data sources

Work-place sampling can be difficult, impractical, time consuming, and, in some situations, impossible if the intrusion caused by the researcher is deemed to be too high. For example, it is unlikely that a technical sales engineer, who has worked for many months to arrange a sales presentation for a high value equipment installation, would agree to have a researcher present at that critical sales meeting. Whereas incentives can be offered, the size of the incentive would have to be extremely high and that would change the nature of the interaction being studied.

Low motivation

If the respondent is surveyed at work, cooperation is required from the company as well as the individual. Higher levels of research intervention are very difficult to achieve in a working environment, because the company is concerned with the effect on worker's productivity and individuals may have little or no motivation to respond. The company and the subjects need high levels of motivation to justify taking time away from work to participate in a research study. Low motivation can cause problems, such as low response rates, incomplete responses and inattentive survey responses, but high levels of incentives to counter low motivation reduce realism by changing the incentive structure in the work environment.

Organizational change

Work-place samples also suffer from unexpected events, such as restructuring, mergers and takeovers that may change the organizational unit under observation or destroy it before the study is complete.

Workforce turnover

Industry workforces generally experience turnover, which can be as high as 25% per year or more. Workforce turnover is a problem in longitudinal studies where the research requires the survey of the same individuals at two points in time.

Low motivation, organizational change and workforce turnover make it difficult to recruit sufficient workers to obtain a statistically significant sample size.

Advantages of student samples

The difficulty of collecting work-place data makes it advantageous to find suitable alternative data sources, particularly for time-consuming research activities such as the development of scales and data collection instruments and testing of longitudinal models. An industry work-place sample is obviously more representative of the population of workers than a student sample, but when work-place samples are unavailable or when the level of involvement is unrealistic for a workplace commitment; a student sample may provide a reasonable alternative. After the scales and model have been tested and refined using the PBL sample, validating them with an industry sample is a simpler exercise.

University students are a research population that is widely used by researchers because they are close at hand to faculty, and are readily available in large numbers (Babbie, 1998). Students are relatively easier to recruit for research than the general population because students may have an interest in research, an expectation to participate in research as part of a course, or they may find the small financial incentives more motivating than the average full time worker. Due to this higher motivation, students are often willing to provide more information and tolerate greater interventions (e.g. longer or more frequent interviews or surveys) than an industry sample. The concentration of students in large numbers also facilitates recruiting. Many researchers recruit new universities students attending entry levels classes to participate in surveys and experiments. Although the higher motivation of university students can bias the student's response, this can be avoided with careful research design and practices.

Human Subjects Guidelines require participation to be voluntary and students cannot be encouraged to participate by threats or rewards in terms of grades.

The data source - Stanford University's PBL A/E/C teams

In our study, we were interested to see whether our model of inter-personal trust validates for the student population, but of even greater interest is the generalization of the results to the population of workers in cross-functional, global industry teams. Thus, for our study the PBL data source represents an artificial setting, like that of an experiment.

To build and test a model of inter-personal trust in cross-functional, global student teams we studied students in cross-disciplinary building design teams. The participants for this study were students in the PBL course "Computer Integrated Architecture-Engineering-Construction", organized by Stanford University's Department of Civil and Environmental Engineering (Fruchter, 1999). It is a project-based course in which global teams of architecture, structural engineering and construction management students design, analyze and plan a $5 million, 30,000 square foot university building. All teams had at least one team member who was not on the same campus and most teams had at least one team member in a different time zone. A unique aspect of this course is that it enrolls students from Stanford and several other universities around the world, giving students the opportunity to experience global teamwork in a distributed environment. The course takes place every year from January to May.

We began our research project with the observation of the A/E/C PBL teams at work to better understand the respondent's understanding of trust in this context (Blaikie,

2000) and identify suitable ways to measure the hypothesized variables of the trust study, e.g. perceived trustworthiness or perceived performance. The study took place in three phases over three years. In year 0, prior to developing a model of inter-personal trust in global teams, we used ethnographic techniques to observe the global teams, and we conducted group discussions with each of the three A/E/C disciplines. We observed and videotaped, from a single location at Stanford University, the distributed team meetings. We conducted group discussions with all participants in each of the three disciplines to develop a general understanding of how trust developed, and to identify strategies for data collection. From this we built our initial model of trust and developed surveys to operationalize the model variables

In year 1, we studied seven teams composed of three to four team members each, distributed across six locations in three countries – the United States, the United Kingdom, and Slovenia. Over five months, we observed and videotaped one side of the distributed team meetings, conducted structured interviews with individual team members, and administered two surveys at two points in time to triangulate the measures (Blaikie, 2000). During the first 2 weeks of the project, we administered an online survey with questions about work experience, the number of courses taken in each discipline, and general trust. Three months into the project, we asked each team member to rate each other team member on the dimensions of perceived trustworthiness, care and ability, to evaluate performance and to indicate the extent to which they checked on the work of each other team member (i.e. our measure of trust). Information on the trustor's perceived risk and reward and the trustor's perception of the trustee's risk and reward

were gathered from structured interviews conducted during the last month of the 4 month project. The interviews were video taped and notes transcribed.

The data collected in year 1 allowed us to test and refine the model. We found that some variables, such as disposition, were not significant and dropped them from the model.

In year 2 we tested the refined model, using our revised scales. We conducted online surveys and structured interviews with 12 teams composed of three to four team members each, distributed among 10 locations in six countries - the United States, Switzerland, Holland, Germany, Slovenia, and Japan. In year 2, as in year 1, a survey during the first week of the project asked questions about the number of courses taken and work experience in each discipline. We also added questions about students' perceptions of their own risks and rewards associated with the project. This allowed us to measure risk perceptions independent of the personal interactions that would occur later in the projects. Approximately one month later and three months later, we distributed dyadic surveys similar to that described in year 1. This allowed us to compare the model variables at two points in time. The use of three surveys also helped us to avoid the "common methods problem" that can be caused by gathering all variables from the same survey instrument.

Thus, we observed the same PBL, operating in the same environment, over a period of three years. This allowed us to develop and test the model in an iterative process.

Key characteristics of a PBL environment as a work-related data source

The following section identifies and discusses the key characteristics of a PBL course as a research sample in a work-related study. Some of these attributes have important pedagogic value affecting the achievement of the educational goals of the PBL course. The optimal design of a PBL course to achieve the research goals may conflict with achievement of the course's pedagogic goals. The resolution of this conflict depends upon the relative value placed on the educational and research goals. The impact of these specific PBL characteristics on the pedagogic value of a PBL environment is beyond the scope of this paper, although general pedagogic advantages and constraints are addressed later in this paper. It is the authors' opinion that, in general, most PBL attributes that increase in the realism of the learning experience are likely to contribute to the achievement of the PBL's educational goals.

The problem similarity

If the problem being tackled in the PBL environment is widely different for each student or team, more variables need to be gathered to control for the task differences, such as task complexity or the level of innovation required. In a work-place sample, the researcher can select, but not control the task being studied. In a PBL, the researcher can assign teams to essentially the same task and thereby minimize the number of variables that must be collected to control for task differences.

For example, PBL teams practicing consulting skills could be asked to solve the same case study problem or they can be asked to find different organizations with

problems to be solved. In the second situation the level of difficulty of the problem could be quite different from one team to the other.

The A/E/C/ PBL task; "to design, analyze, and plan a university building", was essentially the same for all teams but each team was assigned to design a building for a different location, for example a river site, an ocean site, or a site in the mountains. The site difference made the work more individual and realistic, as the teams had to consider the impact of the site on the final design, but the site difference did not significantly change the level of difficulty, nor the essential steps or their sequence, in the project. Therefore we did not feel it necessary to collect data on task characteristics, such as the relative difficulty of the task, or the level of innovation required.

Group assignment procedure

Non-random group assignment procedures, such as assignment based on student preferences (Macdonald and Isaacs, 2001), can introduce bias. If the group is the unit of analysis, team self-selection means that individual characteristics, such as ability, education or experience, are unlikely to be evenly distributed among the groups. Non-random group assignment procedures may be particularly problematic if the group is the unit of analysis for the research, of statistical methods are being used to analyze the results or if team performance is being measured. Random assignment does not create teams with equal skills. It is designed to provide a normal distribution of skills in teams created. This is necessary for the use of statistical methods, which are based upon the assumption of a normal distribution of characteristics in the sample (Hamilton, 1992). Therefore, if the students are allowed to choose their own team partners, the academically stronger students are likely to group together, thus creating teams with an uneven

distribution of skills and personality characteristics. Alternatively, the educator may assign students to teams based on certain assessments of skill or experience. This is a very difficult process and due to the uneven distribution of skills in a class, is unlikely to create teams with equivalent skills. Whereas assignment by skill level may reduce the unevenness of skill distribution, it may introduce bias other ways.

In our case study, the A/E/C PBL students were randomly assigned to groups during the initial face-to-face meeting attended by all students. Each project had a specific characteristic, such as being located in an earthquake zone. Skill profiles that described past experience, such as experience working in an earthquake zone, were distributed randomly to students of each discipline, e.g. architecture profiles to architecture students. In an icebreaking exercise, students identified and joined the project that best suited their randomly assigned skill profile, for example, the student with experience working in earthquake zones would join the project located in an earthquake zone.

This meant that in general we could assume a normal distribution of skills and abilities, although we did test that assumption and found that it was close to normal for the data that we collected on number of courses and years work experience.

Continuity

One of the challenges of our trust study was finding the opportunity to build and test our model through several iterations. Few organizations are patient enough to endure being the subject of a research study that extends over successive project generations.

PBL courses are usually replicated on an annual basis. That provides the opportunity to observe successive classes of students working in the same environment, on the same problem.

In the A/E/C PBL environment, we observed the teams over three consecutive years and collected survey data for the last two years. We were able to repeat our test of the model through several iterations and improve it by dropping variables, such as dispositional trust, that did not prove significant and testing new variables, such as integrity. This allowed us to refine and adapt our research model and data gathering tools. Then, when our tools were mature, we could take our study into the work place.

The sample size

Low motivation and other problems sometimes make it difficult to get a sufficiently large sample size for statistical analysis in work-related studies. Calculation of the sample size depends upon the research unit of analysis; for example, teams, dyads, directional dyads or individuals. Generally speaking, the research techniques employed should be appropriate for the size of the potential sample. Some PBL classes may be more suited to a case study approach because the class size is small or because the unit of analysis is the team rather than the individual or dyad.

In our case study, the unit of analysis was the directional dyad. A dyad consists of two people, person A and person B. A directional dyad is the attitude of person A about person B. In any team of $\mathbf{n}$ team members there are $\mathbf{n(n-1)}$ directional dyads. Therefore in an average team of 3 team members there are 6 directional dyads.

Each year all team members participated in the research. In year 1 we received 61 usable directional dyadic responses (e.g. responses from A about B). In year two our surveys yielded 108 directional dyadic responses. Thus we were able to perform statistical analysis on the data and find some significant results.

PBL work context attributes

One of the criticisms of PBL environments as a work-related data source is that the students do not have the same motivations, risks and rewards, as typical industry workers. We propose that the more realistic the work context created in the PBL environment, the more valuable the PBL as a work-related data source and the more generalizable the results. The following work-context attributes influence the realism of the PBL environment.

Exposure to the professional community

Whereas providing a safe environment to experiment, PBL environments can also shield students from the culture of the professional community with it's associated risks. Whereas the pedagogic benefit of learning the culture of one's chosen discipline seem clear other associated risks and rewards may not be. When the student knows that the performance of the group will be observed by an industry professional, there are professional risks to non-performance and conversely potential rewards for good performance. Therefore, a PBL project based upon a case study where the student has no necessity to contact industry provides no need to ensure that one's questions and behavior fit the professional community's standards of behavior. In contrast, a PBL that requires students to interact with industry provides the opportunity for future employment if the student's work is sufficiently impressive.

The A/E/C/ PBL students were encouraged to consult with the faculty and industry mentors to help solve their technical problems. This close working relationship with respected industry professionals made the A/E/C/ PBL a bridging experience between study and work. PBL courses can develop the student's sense of professional development and identity (Macdonald and Isaacs, 2001) The A/E/C PBL students were well aware that the industry mentors were viewing their work on the project and may recruit them for permanent professional jobs. This introduced the "Shadow of the Future" (Axelrod, 1984) that exists in professional work. The worker knows that his or her performance in the current relationship affects the way the other person will treat him or her in the future.

The problem relevance

The less relevant the PBL problem or project is to the referent work-place, the less generalizable will be the interactions observed in the PBL environment to the work-place population. Conversely, the more relevant the problem appears to be to the student's future work goals, the higher will be the level of realism. For example, if the problem is a mathematical calculation, it could be perceived to be irrelevant to a structural engineering student, unless it is shown to be relevant to the design of a beam.

The A/E/C PBL project was the type of assignment the students could expect to get after working for several years in their field. Overall the project had high relevance for the students and the students were observed to behave in similar ways to what we would expect in an industry setting. For example, we heard the student construction managers make similar comments about the architecture students to those heard from construction managers in industry.

The problem complexity

If the complexity and diversity of the problem, or project is significantly lower than that encountered in industry, the level of realism is reduced. For example, a project such as writing a memo to give advice to a manager is less complex problem than to discuss such a proposal with a manager from a specific company (Segers and Dochy, 2001) and is likely to be perceived to have less realism. Macdonald and Isaacs identify the difference between isolated problems and a "meta-problem" that provides "continuity and depth in terms of the student's focus, resources and questions."(2001, .p 328) The meta-problem is likely to be more real and engaging than an isolated problem.

The problem for the A/E/C PBL project was to design a five million dollar building according to a client's specifications. The challenging "real-life" complexity, nature and size of the problem meant that we were able to observe many interactions, such as relational and task conflicts that we know occur in industry workgroups.

The time frame

PBL projects that only operate for short periods of time are less likely to be perceived as realistic by the participants. A longer time frame provides enough time for the participants to change their work habits, thus making a longitudinal study possible. One of the proposed effects of problem-based learning is the development of a professional identity (MacDonald and Isaacs, 2001). A longer time frame also allows professional identities and relationships to develop, as they would in a real work environment.

The A/E/C PBL teams operated over a period of five months from January to May. This allowed the students to live with the problem and change their work habits, relationships and identities. This was especially relevant when studying social processes that extend over time, like the development of trust. This long time frame allowed us to conduct a longitudinal study by surveying in month 1 and month 3. We found significant differences at these two different time periods that could not have been detected had the project only lasted one month. The longer time frame also allowed for different data gathering techniques to be used, providing a rich collection of data seldom seen in work-place studies. The ability to collect data using more than one instrument can help the researcher to avoid common methods variance (Feldman & Lynch, 1988). Common methods variances can occur when the same instrument is used to gather to all the independent and dependent variables and answers to previous questions prime subjects to provide similar responses to later questions.

Working conditions

If the students' working conditions are not somewhat comparable to industry working conditions, the level of realism can suffer. For example, if most workers have computers but most students do not, there would be problems generalizing from the student sample to the work-place sample due to differences in work methods.

The emphasis in the A/E/C/ PBL course on distributed work and the use of cutting edge commercial technology, not all of which are used by practitioners, made the A/E/C PBL teams reflect the working conditions of the future more so than those of today. Each A/E/C PBL team included at least one member who was not collocated, which is very common in the construction industry. After the two-day project launch, teams did not

meet again face-to-face until the final presentation four months later. Distributed team members communicated mainly through computer-based Internet applications. Internet meeting applications allowed audio and video communication and desktop file sharing. Internet message applications allowed asynchronous message transfer between two or more parties. An Internet application developed for the course facilitated the posting and retrieval of messages and files. Collocated team members used face-to-face meetings as needed. Whereas many workers belong to distributed teams and most workers have access to Internet technology, not all industry workers choose to use the full range of advanced communications technologies provided to the students. Therefore, the A/E/C PBL environment was very realistic in the access it gave students to communication tools, but it was slightly unrealistic in the wide variety of advanced tools available compared to current work resources.

PBL work group composition attributes

The social setting of the PBL environment can contribute to the realism of the experience and it is very important when work-group interactions are the focus of the study. The following work group composition attributes influence the realism of the PBL environment.

Role-play simulation

If the PBL program instructions do not suggest work-related roles, the students may solve the problem or complete the project without assistance to adopt a work-related identity. These students will be less likely to replicate interactions and behaviors found in an industry work place. The adoption of roles in a PBL course enhances the realism of the experience for the learner as the different "actors" provide the student with cues to

appropriate behavior. For example, in a Geographic Information System PBL environment (Livingstone and Lynch, 2000; p. 332) the student's task was to be a group of consultants designing a pilot project to introduce a GIS into the department of the local borough council. Adopting the role of consultant, and interaction with the local council made the experience more realistic for the students than, for example, writing a report based upon a case study.

The A/E/C PBL project was enacted as a role-play simulation with different people fulfilling different roles. The graduate students were "journeymen" assisted by undergraduate "apprentices" and mentored by the "Masters", globally distributed professionals working in each discipline. The "Owner", usually a past student of the course, communicated the client's specifications and requirements to the group. The group had to work within the client's specifications or contact the Owner to request a change. The varied nature of the group, with different professions (architect, structural engineer and construction manager), different roles (owner, worker) and different levels of expertise (apprentice, journeyman or Master) more closely replicated the complex social relationships experienced in a work environment than the typical educational environment.

This use of specialized roles made the A/E/C PBL environment more realistic and comparable to an industry workgroup setting, where individuals have different levels of skill and different roles. The use of different roles, such as "Owner", provided the A/E/C PBL participants with social cues that increased the realism of their experience. For example, when the Owner asks why the proposed solution does not meet the design specifications the student has a more realistic experience than when the teacher asks why

the assignment was late. In the study of trust, we noticed that students were behaving true to their roles when performing their tasks.

Individual versus team projects

If the research study focuses upon work group interactions, the PBL environment should be organized around a team-based project. For example, some PBL programs engage students individually; others revolve around group problems or projects that replicate the social environment of the work place. The research objectives should indicate the suitability of either an individual or group problem.

The A/E/C PBL project was based on a group activity. One student could not do the project alone, partly because there was too much work but mainly because it required the specialized skills of an architect, structural engineer and construction manager. Since our research objective was to study trust relationships between different disciplines, the team setting was appropriate.

Education and work experience

Students with little education or work experience do not provide as good a sample as those who are more similar to the typical industry worker. The closer the student's education is to those working in the industry and the more work experience of the students the more realistic will be their PBL experience. For example, a PBL environment populated with seniors is more comparable to an industry group that has, on average, undergraduate qualifications, than would be a class of freshmen students.

On average, the A/E/C PBL students had taken 12 courses with a focus in their primary discipline, architecture, structural engineering, or construction management. The

students also had an average of 8 months full-time work experience in their discipline domain. Because this was a capstone course in a Masters degree program, the students had as much education and experience as a typical entry-level worker in the industry.

The high level of education of our sample meant that, like professionals in industry, the students had already adopted the professional identities and culture of their chosen discipline. Just as they will encounter specialists in the workplace, they had to act as specialists and interact with other specialists, thus increasing the realism of the experience. These factors were important to our study of trust in cross-functional teams

Cross-disciplinary team composition

PBL environments that have students with similar educational backgrounds, do not replicate the typical heterogeneity of many industry teams. For example, a PBL course in product design is likely to contain students who have completed certain prerequisite courses in mechanical engineering, whereas a product design team in industry is also likely to contain specialists in manufacturing production and marketing.

The A/E/C PBL teams were cross-disciplinary, composed of masters students drawn from United States, European and Asian universities in three disciplines—architecture (A), engineering (E), and construction management (C). The cross-functional nature of these teams increased the level of realism by providing each participant with a specialized professional role, more accurately replicating the heterogeneity of industry teams.

Pedagogic Advantages And Constraints

Using a PBL class as a research data source can provide valuable inputs to course development that could benefit current and future students. Involvement in research increases the organization's level of prior knowledge about the topic and consequently it's absorptive capacity, the "ability to recognize the value of new, external information, assimilate it, and apply it" (Cohen and Levinthal, 1990, pp 128). This process should apply to educational institutions and PBL just as to commercial organizations.

For example, if the research objective is descriptive, the educators will have access to information about student interactions that is likely to be useful in designing course improvements. If the research project aims to test a new work tool or procedure, future students will benefit from the knowledge gained about the usefulness of the innovation.

The research conducted with the A/E/C PBL has lead to numerous course improvements and tools, some of what are so promising as to be patented and commercialized by Stanford University.

The general goal of problem-based learning is to provide students with an opportunity for experiential learning in a supported environment that will facilitate the transfer of knowledge from the educational context to the professional context (Candy and Grebert, 1991). With this objective, any increase in the realism of the work context or the workgroup composition would usually facilitate the learning experience, as long as a sufficient level of student support was maintained. But, to increase realism by withdrawing educational support would create a conflict with the pedagogic goals in most

cases. Except for such examples, in general the researchers' and the educator's goals are both better achieved when the realism of the PBL experience is increased.

In contrast, there could be a conflict between pedagogic and research goals when researchers exercise their control to create experimental interventions. For example, in the A/E/C PBL research project, we considered dividing the class into a control group and experimental group and providing extra training to the experimental group to see if that would affect their level of trust and performance. We decided not to use that research design because it would be difficult at the end of the course to readjust the grades to remove the presumed advantage provided to half of the students by the additional training, and the other half of the students would miss out on the benefits of the training. Ultimately, we felt that it was not equitable to provide advantages to some students and not to others. Adopting this standard constrains the use of experimental interventions in a PBL environment. Such limitations are not unusual in any research environment, since "Human Subjects" standards tightly regulate the way that subjects can be treated in research studies.

PBL data sources have Human Subjects considerations in addition to those normally considered for a research project by virtue of the fact that the research subjects are students and their grade could affect their future work opportunities. Therefore, the research design cannot be allowed to interfere with the learning opportunities of the course or "the level playing field" upon which the assessment and evaluation of the student's performance are based. The research design should not interfere with a student's ability to compete for a grade on an equal basis with other students. Therefore the research design cannot unduly advantage or disadvantage any students. For example,

a research design that provides an experimental stimulus to the experimental group of students but not the control group must be considered very carefully to ensure it does not advantage or disadvantage the experimental group. It is difficult to guarantee fair grading when one group of students has a more challenging task or fewer resources.

Discussion and contributions

This paper shows that, depending upon the population of interest a PBL data source can provide a natural, semi-natural or experimental setting. In the case of a work-related study, a PBL data source provides an artificial setting that can be more realistic than a social science laboratory experiment, and the PBL can provide an opportunity for longitudinal studies, but with some restrictions on the level of experimental intervention available.

When evaluating a PBL as a data source the greater the realism of the work context and the workgroup composition, the more realistic will be the PBL and the better it rates as a data source. Indeed, when relevant and complex project-based problems are tackled in industry-like work conditions over longer time frames the PBL can be very realistic. Similarly, when participants with industry-level education and experience enact specialized roles in different disciplines and interact with the professional community the realism of the PBL can be very high.

Organizational features of the PBL can also contribute to the quality of the research design, such as random allocation of subjects to groups, similar group projects, continuity from year to year and research techniques appropriate to the potential sample sizes.

The fact that PBL projects can be enacted over a longer time frame than a typical synthetic experiment - in our case study 5 months - makes PBL a potential research data source for longitudinal studies. In addition, since the PBL class may be repeated, it provides an opportunity to develop and test models in an iterative process of building, testing, revising and retesting.

Limitations and future research

Despite the level of realism achieved, PBL is an artificial replication of a work-place data source, and the question of generalization to the work population remains.

This highlights the need for research studies to compare the results from matched studies differing only in their use of PBL versus workplace data sources. Comparative research to benchmark the potential generalizability from the PBL data source to the workplace populations would be helpful.

In the case of our A/E/C PBL case study, we found inconclusive relationships between the situational variables, risk and reward, and our dependent variable, trust. One of the strategies of any educational environment is the reduction of risk to encourage the student to experiment and learn. In an industry setting, the risks are real. These strongly motivate, and are highly relevant to, trust. Therefore, we believe that the relationship between the variables risk, reward and trust would be much clearer in an industry sample.

Conclusion

As the use of problem-based learning increases, more variation in PBL design is likely to occur and more researchers will take advantage of the opportunities PBL environments offer as a research data source. This paper uses a case study of a research

project investigating trust in cross-functional, global teams to illustrate key characteristics of a PBL as a research data source. The case study research project, Trust in Cross-functional Global Teams, used Stanford University's Civil Engineering PBL as a work-related data source. We propose that the more realistic the PBL work context and workgroup composition, the better the PBL data source as a proxy for an industry sample. PBL course design can also contribute to the research design by using random assignment to teams, annual continuity, and research techniques appropriate to the sample size.

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Chapter 5

Contributions and suggested future research

The trends toward teams with greater functional diversity and greater geographical distribution are creating new social environments for knowledge workers. Functional diversity and geographic distribution make the development of trust more difficult, and simultaneously, more important.

In this research trust is defined as the willingness to accept a risk based upon the expectation that another party will perform, regardless of your ability to check (Mayer, Davis and Schoorman, 1995)

To address these issues, my research question was:

Of the many variables that have been proposed to affect trust, which variables, when examined together, are the most important predictors of trust in cross-functional distributed teams?

The methodology I chose was to build a model of inter-personal trust and test it in cross-functional, global student teams.

The preceding three chapters described the three-year process of model building and testing and the learning that came from that process. Chapters 2 and 4 will be published as autonomous journal articles. Chapter 3 will be published as a chapter in a book on trust in an organizational context. This chapter gathers together the contributions of these papers, outlines a plan for future research and concludes with some closing remarks.

Contributions to knowledge and suggested future research

This section outlines the contributions that my research makes to knowledge in three fields—social theory, organization theory, and engineering management—and to social research methodology and education.

Contributions to social theory

This research makes a number of contributions to the understanding of inter-personal trust in a work related context. The central contribution is the validation of an integrated model of inter-personal trust. The model was tested using longitudinal, as well as case study and survey methods. Evidence was found for the striking difference that context plays in the development of inter-personal trust. Central to the research question is the observation that some variables, such as perceived trustworthiness, which were influential on their own, were not found to be significant when combined in the model with other variables, such as perceived performance. This allowed us to determine the ordering of antecedent variables.

Validation of a model of inter-personal trust

In general, my model of inter-personal trust was validated. I found strong correlations between trust and care, ability and integrity, which are the dimensions of perceived trustworthiness. I also found significant correlations with other antecedent variables, such as trustor's risk and reward.

This appears to be the first time that a model of inter-personal trust has been tested and validated at the dyadic inter-personal level. Most studies on trust in an organizational context have focused on trust at the group level, for example the trust of

workers for top management (Mayer and Davis, 1999). Although this is a valuable perspective, trust is an aspect of all personal relationships. The long-range strategy of this research is to test a model of trust at the inter-personal level and then add additional complexity to account for organizational constructs such as teams, departments or organizations. My model of inter-personal trust provides an initial platform to which other variables can be added, and from which we can scale up to making team or organization-level predictions through techniques like agent-based simulation.

Lack of evidence for dispositional trust

I did not find a strong correlation between trust and the dispositional variable, propensity to trust in the first year of my research and therefore dropped it from further analysis. I believe that this variable, which has proven to be significant in laboratory experiments, may not maintain its strengths in a work context. It is possible that previous laboratory experiments only measured the attitudinal aspects of trust, rather than the behavioral aspects, which we measured. It is possible that the influence of disposition on trust may be exaggerated due to the "Fundamental Attribution Error" (Ross, 1977), in which individuals have a tendency to attribute behavior to an individual's disposition rather than the situation. Further research is needed to continue investigating the possible influence of the trustor's personality on the trust in different contexts.

Reward as well as risk

We found that, not only does risk play a part in trust, but so, too does the trustor's perceived reward. When the antecedent variables of risk, reward and perceived trustworthiness were combined together in the regression analysis, perceived

trustworthiness maintained it's predictive strength, and risk and reward did not. Never the less, in the AMOS structural equation models reward maintained its significant relationship with trust, whereas in distributed teams, risk was the significant factor. There is an opportunity to delve further into the relationship of risk and reward to perceived trustworthiness, and their relationship to trust.

This extends the Mayer, Davis, & Schoorman model of trust by adding the dimension of reward and more completely accounting for the situation. Adding reward to the model recognizes the importance of motivation in the development of trust and explains why individuals will trust even when the risks are high. It is possible that the influence of risk and reward on trust was weaker in this study of student teams than it would be for workers in organizational settings.

Perceived Performance

The measurement of perceived performance explicitly tests a mechanism for 'history-based trust", which is the development of trust over time. As expected I also found a high correlation between perceived performance and perceived trustworthiness. When this relationship was tested I found that, particularly in distributed dyads, perceived performance mediated the relationship between perceived trustworthiness and trust. This relationship is particularly important because if perceived performance, which influences trust, does not accurately reflect actual performance, team members may be making trust errors of unwarranted trust or unwarranted distrust. Further research is suggested to investigate the relationship between perceived performance and actual performance in these distributed teams.

Snapshot and longitudinal validation

In addition to testing the model at one point in time, the model was tested in a longitudinal study comparing two points in time. I found that although trust, perceived trustworthiness, and perceived performance showed a tendency to remain stable over time, some variables at $time_1$ influenced the value of other variables at $time_2$. For example, as predicted, perceived performance at $time_1$ predicted perceived trustworthiness at $time_2$ also checking at $time_1$ predicted perceived performance at $time_2$. This longitudinal validation was important due to the need to test history-based influences on trust.

Collocated versus distributed context comparison

Contrary to models of trust development in traditional teams, our analysis, also suggests that perceived performance mediates the relationship between perceived trustworthiness and trust in distributed dyads. It appears that participants relied on their perceptions of their team members to evaluate the extent to which these team members met expectations.

I also found evidence that trust is more stable in distributed dyads - it increases less, but it also decreases less than in collocated dyads. Members of distributed dyads appear to retain stable perceptions of their team members' trustworthiness that, in turn, affect their perceptions of team members' performance. In contrast, collocated dyads appear to update their perceptions of trustworthiness based on their perceptions of their team members' performance. It is possible that collocated dyads have other opportunities

to gather information about the trustworthiness of their partners through chance meetings or social outlets.

My comparison of the model of trust in distributed and collocated dyads provides evidence that, as suspected, trust is very context sensitive. I found interesting differences between collocated and distributed dyads that sheds some light on how the new global teams and the use of technology for communication are changing the social context of work. Future research is needed to compare the type and amount of communication exchanged between distributed and collocated dyads.

A trusts B about X when Z

This research provides clear evidence that trust is influenced by the context and that the model of trust may vary from context to context.

Future research is needed to test this model in different contexts and possibly identify the salient contextual variables that might predict the appropriate model for the context. It is my suspicion that the amount and type of information exchanged within a dyad influence the development of trust.

Effect of trust on performance

Whereas the effect of trust on performance was not part of my research question, I could not resist analyzing the relationship between trust and our measure for performance, the student's grade. We did not find any significant relationships between trust and either the trustor's grade or the trustee's grade. This is not surprising considering that the relationship between risk and performance is not consistently shown

in other studies and is often mediated by motivation (Dirks, 1999), which we did not measure.

Development of scales

In order to test the variables in my model in ways that were consistent with the theoretical understanding of trust, such as "**A** trusts **B** about **X**", I developed, tested and modified scales for care, ability, risk, reward, perceived performance and trust. These scales had high alpha values when tested.

Contributions to organization theory

Inter-personal relationships are the building blocks of organizations. The dyad is the lowest micro-level of organizational interactions. Ultimately all actions are individual actions and all human-to-human relationships have some level of inter-personal interaction. Since trust is fundamental to all human relationships, a valid model of dyadic trust is an appropriate starting point for understanding trust in organizations, provided there is some mechanism for extrapolating from the personal to the organizational. Computer-based simulations and computational models can provide that mechanism. (Carley, 1999) They embed micro-behaviors in agents and then model agent interactions to generate meso- and macro-level outcome predictions that can be compared with meso- and macro-level empirical observations.

This research provides a model of inter-personal trust that can be used in a wide variety of ways to better understand organizations.

In the research arena, this model can be built into agent-based simulations of organizational behavior to demonstrate the emergent effects of trust on organizational

performance. Simulations used to extrapolate social theories, such as the Virtual Design Team (VDT) (Levitt, 1994), can move from the current, naive assumptions of absolute trust between all team members to more realistic assumptions about the gradual development of trust and its effect on behavior, based upon the validated model of trust.

Contributions to engineering management

This research is relevant to engineering management, because as the specialization of technology increases, teams are more likely to contain cross-functional dyads and the impact of cross-functional issues increases. This section describes some of the contributions of my research to training, work practices and management in engineering.

Training

In the training arena, the model of inter-personal trust can be used to provide more effective teambuilding training. Current teambuilding practice seeks to promote the increase of trust in all situations. Based upon our model, we would not promote high trust in all situations; we would promote no unwarranted trust as well as no unwarranted distrust. For example, in situations of high risk, low reward or low trustworthiness of the trustee, it is more appropriate to change the situation than to promote increasing trust. Hence it might be more advantageous to long term trust to change the reward structure of the trustor or the trustee, or to increase the ability of the trustee through training. This model allows managers to analyze and diagnose team situations with greater precision and to apply interventions with greater discrimination. In the practical arena, this model can provide guidance to members and managers of cross-functional and global teams.

Work practice

Team members can be taught how to better manage their trust relationships. They can learn how to reduce their level of risk by forming more accurate expectations of other team members' performance through the discussion of basic assumptions. Team members can learn trust-building strategies to use in high risk situations, such as reducing the size of the task ("**X**"), or shortening the time between trust and the evaluation of perceived performance. Workers can also be taught the value of being trustworthy as a technique for developing trust. Finally, workers can be taught how to avoid common pitfalls, such as changing their expectations from the time of trust to the time of evaluation of performance.

Management

Managers can see from the model that building trustworthiness is less risky than promoting trust. They can use the model of trust to diagnose work situations and identify appropriate interventions. They can learn how to encourage trust by providing fast and accurate information systems that provide trust-relevant information. Finally, managers can develop a team or organizational culture that values accurate expectations over high expectations.

Contributions to education and research

With the increase in the use of project-based learning (PBL) comes a wide variety of PBL courses and a corresponding increase in the use of PBL as a research data source. These trends make the identification of the key characteristics of PBL environments as a

data source for work-related studies an important contribution to guide the design of PBL environments and the evaluation of those environments as a research data source.

Methodology for model validation

This research provides a methodology for model validation using project-based learning environments.

The methodology is based on an iterative process that cycles through the steps of model design, model testing and model redesign. The process progresses from the use of qualitative research techniques, such as observation, to identify opportunities to operationalize model variables to the use of quantitative techniques, such as surveys, to test the model relationships. The use of the PBL environment makes it possible to progress through the methodology in the relatively constant PBL environment, so that when the model is taken into the field for testing it is somewhat mature. This reduces the amount of fieldwork that is required in industry studies.

Key characteristics of PBL environments for work-related studies

I identify key characteristics of PBL environments as a data source for work-related studies. These characteristics can provide a template for the design of highly realistic PBL environments for work-related studies. I also discuss some areas in which the pedagogic and research goals of a PBL course might clash and suggest appropriate resolution of these conflicts. Future research is needed that will compare the results from work-related studies using PBL environments with those using industry data sources.

Closing remarks

In my research proposal "Modeling and monitoring trust in virtual A/E/C teams" I asked the following research question: *Of the many variables that have been proposed to affect trust, which variables, when examined together, are the most important predictors of trust in cross-functional, distributed teams?*

The research plan mapped out in my proposal was designed to answer this question. Now that I have carried out that plan, it is appropriate to evaluate the extent to which I answered the research question.

I propose that the research plan, as described in the preceding three chapters more than adequately answers the research question.

I developed and validated a model of inter-personal trust that indicates the most important predictors of trust in cross-functional, global teams. I collected data over a period of three years. In two of those years I had sufficient data to perform analyses with statistically significant results. From this analysis I was able to detect direct correlations between the independent variables, perceived trustworthiness, risk and reward, and trust. In addition, I was able to perform multivariate regression analyses to determine what factors, when examined together, were the most significant predictors of trust.

The use of student teams, the small sample size and the lack of a comparison between uni-functional and cross-functional teams are limitations of my research. Nevertheless, the research is applicable to many teams in practice that are multidisciplinary and distributed, and its results offer valuable insights to managers of such teams.

As explained in Chapter 4, the use of the project-based learning teams is only a limitation when the population of interest is industry workers. If our population of interest is students in project-based learning teams, then the data was collected in natural or semi-natural settings and the model validation is directly generalizable to that population.

The small sample size means that we may have missed some correlations that could have been found with a larger sample. It does not negate the statistically significant correlations that were found. The fact that we found significant correlations with such a limited sample size highlights the strength of the relationships that must exist in the data.

The lack of a comparison between uni- versus cross-functional dyads leaves us wondering whether we might have found other ways that the model of trust differs in certain contextual situation. It does not detract from the confirmation of the relationships that we found in the cross-functional dyads that were studied.

Rather than detracting from the ability of this research to answer the research question, these research limitations provide opportunities for future research to validate this inter-personal model of trust in industry teams, with larger sample sizes or with comparisons between uni-functional and cross-functional teams.

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