Knowledge Utilization, Coordination, and Team Performance

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Abstract

Considerable research has established the superior performance of teams on which team members utilize specialized knowledge and also develop transactive processes that promote coordination. Less is known, however, about the consequences for team performance when team members only possess one of the two productivity factors. We develop and test a framework highlighting the distinct challenges these teams will face. In particular, our results show that each productivity factor contributed significantly more to team performance when the other factor was present. And our findings also illustrate a potential failure mode for knowledge utilization. If team members could not coordinate their collective efforts, utilizing knowledge undermined team performance. Our framework outlines a similar risk for too much coordination, if team members cannot utilize their specialized knowledge and are asked to perform a task with a "rugged" performance landscape. We discuss the implications of our framework and results for theory and practice.

Keywords: Teams, transactive memory systems, coordination, knowledge utilization, specialization

As work become more interdependent and it becomes more difficult for a manager to know *a priori* what members of an organization should produce and how they should organize their workflows and activities, more work is being accomplished in the team context (Leavitt, 1996). Utilizing teams represents a shift away from planning and toward more feedback-based learning that direct collaboration can introduce. Given the shift in how work is being accomplish, how to improve team performance is an active research area (McGrath, 1984; Hackman, 1990; Kozlowski and Ilgen 2006), with particular attention in recent years to teams as information-processing units with distributed cognition (Hinsz, Tindale, and Vollrath, 1997; Argote, Gruenfeld, and Naquin, 2001; Edmondson, Dillon, and Rolloff, 2007; De Church and Mesmer-Magnus 2010). One form of distributed cognition is a transactive memory system (TMS). A TMS is a cooperative division of labor for acquiring and applying specialized knowledge and expertise (Wegner, 1987). Colloquially, a TMS is known as knowledge of who knows and does what on a team. Wegner, Guilano and Hertel (1985) noted that a TMS has two components: the specialized knowledge and expertise possessed by each individual team member and the set of transactive processes that occur among group members that allow them to coordinate the application of their specialized knowledge and expertise. The two components that define a TMS, the utilization of specialized knowledge and expertise by each individual team member and the effective coordination across individual members, are the focus of the current study.

Prior research has established that teams that solve knowledge utilization and coordination-related problems perform better than teams that do not (see Ren and Argote 2011, for a review). The research findings, while informative, also highlight a potential dilemma facing any manager or team leader who is interested in shaping initial team performance. The best teams utilize specialized knowledge and coordinate team members' behavior, but getting a team to do both initially can be problematic. Indeed, developing specialized work roles and responsibilities can make it more difficult for team members to coordinate their behavior, while too much attention to effective collaboration can detract from team members' ability to develop specialized knowledge and expertise (Polanyi, 1967; Tushman and Katz, 1980; Lounamaa and March, 1987; Levinthal and March, 1993). And thus, a team leader is often presented with a choice that could trade off two key elements of team performance. The leader could encourage team members to focus on creating and using specialized knowledge, and risk effective coordination. Or the leader could encourage team members to focus their efforts on figuring out how their different activities fit together, which could come at the expense of deepening their specialized knowledge and expertise.

Even if a team leader or manager can avoid potential tradeoffs between knowledge utilization and coordination, he or she could discover a related challenge. A manager could learn that each productivity factor is beneficial when combined with the other factor but contributes considerably less to team performance by itself. Existing research findings provide very little guidance for managing this challenge. A large number of studies have established the importance of knowledge utilization *and* coordination for superior team performance. And yet, we know very little about how teams perform when one productivity factor is present but the other factor is absent because previous research has focused on the teams along the diagonal in Table 1. Research findings indicate that teams in the fourth cell (high knowledge utilization and high coordination) perform better than teams in the first cell (low knowledge utilization and low coordination). We know less about the off diagonal teams in Table 1. We see considerable merit in evaluating the performance of off diagonal teams. Not only would our findings illuminate the choice facing the team leader described above, they would also advance theory about team performance. Indeed, we argue that not only is each productivity factor less beneficial when the other factor is absent, each factor has a distinct performance failure mode which is more likely to be realized when the other factor is too low. We present evidence that indicates that if one productivity factor is low, an increase in the other factor could end up reducing team performance. Thus, there are times when off diagonal teams will perform worse than teams low on both productivity factors.

The manuscript is organized as follows. We first develop theory relating knowledge utilization and coordination to team performance. We then describe the methods and results of a laboratory study that we conducted to test our theory. Finally, we close by discussing the theoretical and practical implications of our findings.

Transactive Memory Systems: Knowledge Utilization and Coordination in Teams

When team members have developed work roles and responsibilities that allow them to create and use specialized knowledge and have also figured out how to coordinate their behavior, the team is said to have developed a TMS (Wegner, 1987; Wegner, Giuliano, and Hertel, 1985). Many studies have found that well-developed transactive memory systems improve team performance (see Ren and Argote 2011, for a review). These studies have been conducted in both the laboratory (Holllingshead 1998; Liang, Moreland, and Argote, 1995) and field (Austin, 2003; Faraj and Sproull, 2000; Lewis, 2003) and included a variety of performance indicators, such as product quality (Liang et al., 1995) and time to completion (Faraj and Sproull, 2000). A TMS is a form of team cognition. A recent review of the literature on team cognition concluded that team cognition was a significant predictor of team performance (De Church and Mesmer-Magnus, 2010).

With respect to specialized knowledge and expertise, developing a TMS can improve team performance for two related but distinct reasons. First, when a team develops a knowledge-based division of labor, team members learn, accumulate knowledge and develop skills at a faster rate than their less specialized counterparts (Flueckiger, 1976). Individuals with specialized knowledge and expertise can focus on the knowledge and skills relevant for their particular parts of the task and develop deep expertise and skills in those areas (Dane, 2010). Second, when team members specialize in different aspects of the team's task, individual tasks can be assigned to team members most qualified to perform them, further increasing knowledge utilization (Woolley et al., 2007). Teams that develop a TMS end up creating a larger pool of knowledge and skills than teams that do not develop a TMS and teams that develop a TMS also are more likely to utilize whatever specialized knowledge and expertise they have created and developed.

In addition to differentiated knowledge, superior team performance requires coordination. Prior research has documented the importance of different kinds of coordination, including unprogrammed (March and Simon, 1958) or relational (Gittell, 2002) coordination that occurs among team members as they accomplish their tasks. This kind of unprogrammed or relational coordination often forms and adapts as the team performs its task (Faraj and Sproull, 2000) and has been found to contribute to team performance, especially under uncertain conditions (Argote, 1982). As team members work together, they develop their own language and short-hand terms to describe elements of their work context (Weber and Camerer, 2003). The common language, which includes verbal and nonverbal components, reflects how team members represent their environments (Lazear, 1999). The shared language facilitates communication (Krauss and Fussell, 1991), which enables team members to coordinate their activities more effectively (Clark and Marshal, 1981) and thereby improves their performance (Weber and Camerer, 2003).

Scholars have adopted two distinct approaches to investigate the effect that developing a TMS can have on team performance. One approach is indirect and invokes the concept of TMS to explain the positive association between experience working together and team performance. The positive effect that experience working together can have on team performance has been documented in a variety of teams, including surgical teams (Pisano, Bohmer, and Edmondson, 2001; Reagans Argote and Brooks, 2005), software development teams (Boh, Slaughter, and Espinosa, 2007) and manufacturing assembly teams (Argote and Epple, 1990). Experience working together has been found to provide team members with opportunities to learn who knows what and therefore to divide their labor to utilize expertise available on the team most effectively. Experience working together has also been found to provide team members with opportunities to learn how their expertise and skills "fit" together and therefore, how to work as a collective unit. Researchers using the indirect approach suggest that the association between experience working together and team performance can be attributed to the development of transactive memory systems and the corresponding increase in knowledge utilization and coordination. Others scholars have taken a more direct approach and have measured knowledge utilization and coordination. Researchers working in this tradition sum measures of knowledge utilization and coordination to form a measure of transactive memory and analyze the relationship between this composite measure and team performance (Liang, Moreland, and Argote, 1995; Lewis, Lange, and Gillis, 2005).

We have learned a great deal by considering the joint influence of knowledge utilization *and* coordination on team performance. And yet, we see the potential to make empirical and theoretical progress by "pulling" the two productivity factors apart and considering their independent and joint contributions to team performance. Although knowledge utilization and coordination have been found to correlate highly in laboratory research, the two have been found to correlate only modestly or not at all in field studies (Ren and Argote, 2011). For example, Akgun et al. (2005) found a moderate positive correlation ($r = .29$, $p < .05$) between knowledge utilization and coordination, while neither Faraj and Sproull (2000) nor Michinov et al. (2008) found a significant relationship between knowledge utilization and coordination. Thus, although prior research has focused on the presence or absence of knowledge utilization *and* coordination, the two productivity factors are conceptually and empirically distinct.

To appreciate why it is important to pull the productivity factors apart, it is important to remember what effective teams do. Superior teams select and implement the best solutions to a given problem. Existing research suggests that off diagonal teams should experience difficulty accomplishing these goals. If a team is composed of experts, each one is likely to define the team problem and corresponding solution differently from individuals who are expert in other domains (Dearborn and Simon, 1958). If the experts have developed transactive processes that allow them to consider the performance implications of their individual choices, the team is likely to converge on a good solution. To be clear, we are not assuming that effective teams search the solution space collectively (i.e., through joint search). We are assuming that if team members can communicate the potential performance implications of their individual choices, as each individual team member explores a solution space, he or she is more likely to converge on a good choice for the team. If the experts are unable to share the implications of their individual choices, each one is less likely to consider their ideas from the perspectives of other team members and each one is more likely to myopically focus on the best ideas and solutions in his or her domain. When experts are unable to anticipate or react to each other's choices, even if team members manage to converge on a good solution, they are likely to waste considerable time and effort along the way. The team is likely to experience significant process loss and settle on a solution that underutilizes the knowledge and expertise available on the team. Thus, the accumulation of specialized knowledge and expertise can make it difficult for team members to coordinate their behavior.

And if experts are unable to consider the perspectives of their team members when utilizing what they know, utilizing specialized knowledge and expertise can be less beneficial for team performance. This rationale suggests that knowledge utilization improves team performance when team members also have a capacity for collective action, but improves team performance to a lesser extent when they do not.

Hypothesis 1: Increases in knowledge utilization improve team performance more when coordination is high than when coordination is low.

Along similar lines, we expect for coordination to be most beneficial when coupled with knowledge utilization. When team members attempt to develop a solution to their problem, they must converge on a good solution for the team. We have argued that experts who are not able to share their views and perspectives are likely to end up with a relatively large number of disparate solutions. Non-experts who can coordinate are likely to end up with too few choices. When team members have developed a capacity for collective action, they are less willing to search for information and explore a solution space (Tasa and Whyte, 2005), which can result in the team pursuing less than optimal solutions. When non-experts can coordinate their behavior, they are more likely to converge on a solution that meets minimum requirements, instead of continuing to search for better team solutions, even when superior alternatives are within their reach. This line of thinking leads to the following prediction.

Hypothesis 2: Increases in coordination improve team performance more when knowledge utilization is high than when knowledge utilization is low.

Hypothesis 1 and 2 are derived from the assumption that instead of being additive, the two productivity factors are multiplicative. Each factor contributes more to superior performance when the other factor is also present. But the discussion above also suggests that an increase in either productivity factor could undermine team performance. In particular, we would expect to observe significant process loss when experts are unable to share their views. The experts pull the team in different directions, which makes it difficult for them to achieve their collective task, if at all (e.g., see King and de Rond, 2011). Unless spending more time and effort within each domain introduces productivity gains that offset the negative implications of process loss, utilizing specialized knowledge and expertise could undermine team performance. Alternatively, if there is something to gain by continued search and exploration within each domain, satisficing and coordinating around an idea too quickly could also undermine team performance. Random experimentation and search in the team's solution space could yield better outcomes.

Thus, each off diagonal cell has a productivity failure mode that, if realized, could harm performance. To evaluate the relative performance of teams in the off diagonal cells, it is important to know when these negative implications are likely to occur. We believe a key contingency is the degree of interdependence characterizing a team's task. Two activities in a team's task are interdependent if the value created by performing one activity depends on performing the other activity (Puranam et al., 2012: 421-422). While interdependence is often used to describe the potential value created by linkages between team members' work roles and responsibilities, it can also be used to describe potential solutions to the problem a team has been assigned. Two team members are more interdependent, in the team's solution space, if the value of one member's knowledge and expertise is contingent upon how another team member utilizes his or her knowledge and expertise. As interdependence increases, some combinations of team members' knowledge and expertise are significantly more valuable than other combinations (Levinthal and Warglien, 1999: 347-348). We use process interdependence to refer to the linkages between team members' work roles and activities. When process interdependence is high, team members performing different activities require input from other team members to successfully complete their task. At the extreme, each team member requires input from every other team member to successfully complete his or her task. Scholars have used a number of terms to refer to this condition, including "tight coupling" (Lawrence and Lorsch, 1967) and reciprocal interdependence (Thompson, 1967). An example is a hospital surgical team. The activities of one team member affect the activities of another whose activities in turn affect the first team member. Software development teams and film crews (e.g., camera people, electricians, and "grips") are also examples of teams high on process interdependence. If team members can complete their task with little input from other team members, process interdependence is low. Activities on the team are more "loosely coupled" or nearly decomposable (Simon, 1965). Sales teams are an example.

We use output interdependence to refer to the value created by linkages between team members' knowledge and expertise in their solution space. When output interdependence is high, the team's solution space is more "rugged" because some combinations of the team members' specialized knowledge and expertise are valuable, while other combinations are not. An example would be a product development team during the concept development stage. During the concept development stage, team members spend a significant amount of time looking for different ways to combine their specialized knowledge and expertise to create some new product or service. When output interdependence is low, the team's solution space is less rugged and superior solutions require that each team member apply his or her specialized knowledge and expertise. Team members do not need to spend as much time considering how to combine what they know.

Output and process interdependence determine how much knowledge utilization and coordination contribute to team performance, thereby influencing which productivity failure mode discussed above is more likely to occur. In particular, as process interdependence increases, coordination has more of a positive effect on team performance, and as output interdependence increases, knowledge utilization has more of a positive effect on team performance, especially when team members possess specialized knowledge and expertise. Thus, when process interdependence is high and output interdependence is low, coordination has a large effect on team performance and knowledge utilization has a smaller effect. Since knowledge utilization has a smaller effect on team performance, the potential process loss knowledge utilization can introduce is unlikely to be offset by the benefits knowledge utilization can provide. When process interdependence is low and output interdependence is high, knowledge utilization has a large effect on team performance, and coordination has a smaller effect. Under this condition, any potential process loss that continued search within a domain introduces should be less problematic because knowledge utilization is likely to be beneficial. Ending search prematurely would be more problematic.[1]

Therefore, when output interdependence is high and process interdependence is low, high knowledge utilization and low coordination teams (teams in cell 3 of Table 1) should do better than low knowledge utilization and high coordination teams (teams in cell 2 of Table 1). However, when output interdependence is low and process interdependence is high, high knowledge utilization and low coordination teams should do worse than low knowledge utilization and high coordination teams. We have selected a task that is characterized by low output interdependence and high process interdependence. Thus, we test the following prediction:

> Hypothesis 3: Teams in the high coordination and low knowledge utilization condition perform better than teams in the high knowledge utilization and low coordination condition.

Although we focus on a task that is characterized by low output and high process interdependence, which limits the scope of our findings, our research findings can have important implications for research on teams. A significant amount of work is accomplished in teams that are low

[1] A focus on output and process interdependence allows us to clarify when the productivity losses we have identified are more likely to undermine team performance. We are not suggesting these losses do not occur when both kinds of interdependence are high. They can. We are assuming that each factor can introduce productivity gains and losses. When both output and process interdependence are high, it unlikely any losses a factor can introduce will be large enough to offset the gains the same factor also creates. Thus, the framework we are developing could help to explain when teams that are high in output and process interdependence underperform given the levels of knowledge utilization and coordination observed on the team.

in output interdependence but high in process interdependence. In addition to more traditional manufacturing or production teams, consulting, medical, and software development teams are examples of teams that are low in output interdependence but high in process interdependence. Further, for teams that perform a task that is high in output and process interdependence, the characteristics of the team's task can change once a solution has been identified. Consider the new product development teams we discussed above. Once a new innovation has been identified, team members, which could be composed of completely new people, has a task with more clearly defined scope parameters in their output or solution space (i.e., low output interdependence), but the activities among different team members are likely to remain highly interdependent because the organization has little experience with manufacturing the new product or delivering the new service. And thus, an organization's ability to capture whatever value the new innovation could create will often depend on the performance of a team asked to perform a task that is low in output but high in process interdependence. So while we have selected a task that only allows us to test part of our argument, we believe the empirical results will have significant implications for a number of important teams inside of organizations.

Methods and Data

Data for our study were collected at two universities. Two hundred and sixty seven students in a medium-sized Eastern University participated in the study in exchange for class credit. Two hundred and thirty seven students in Israel participated in the study in exchange for payment. The same instructions were used at both locations. In Israel, the experiment was conducted in Hebrew. Instructions were translated from English into Hebrew using back and forth translation (Brislin, 1980). Participants were randomly assigned to three-member teams and to one of four experimental conditions in a between-subjects factorial design: 2 (knowledge utilization: low vs. high) X 2 (language: unshared vs. shared). One factor in the design was knowledge utilization, which we created by varying the extent to which participants were able to utilize knowledge and expertise during the performance phase of a task they had acquired during a training phase. The ease of achieving coordination was varied by providing members of half of the groups the same terms to describe task components and providing the other half different terms.

The study consisted of two main phases: training and performing. The training phase included a learning session and a memory test that was completed by each individual in isolation. The performance phase consisted of an assembly task that was completed in teams. Our dependent measure was the completion time of the assembly task, during the performance phase. The participants in the US were given up to 20 minutes to complete the assembly task. Pilot results in Israel indicated that subjects were less familiar with K'NEX than subjects in the US, so the subjects were given an additional five minutes to complete the task. In both the training and performing phases, participants built K'NEX models that shared similar motifs. These motifs, which were used to manipulate knowledge utilization, are shown in Appendix A. In the training phase participants were trained to assemble the Taj Mahal; in the performance phase they built a replica of the Eiffel Tower. The participants were told they would not build the same models in the training and performance stages of the study.

The knowledge conditions were designed to manipulate how much team members utilized knowledge they acquired during the training phase. We trained each team member to make one part of the Taj Mahal (i.e., hall, pole or cupola). During the performing phase, the teams assembled the Eiffel Tower. The models in the training and performing phases were not identical, but included similar parts and required similar assembly techniques. In the high knowledge utilization condition, team members assembled parts in the performance phase that were similar to the parts they had assembled in the training phase. We provided the teams with a rational for matching expertise: *"Generally, the most effective teams are those in which team members' tasks match their expertise. Therefore, in this task, you will perform a task similar to the one you performed in the training session."* In the low knowledge utilization condition, team members assembled parts in the performance phase that were dissimilar to the parts they assembled in the training phase. These teams were also provided with a rational for expertise mismatch: "*Generally, the most effective teams are those in which each member masters all task elements and, in case needed, can cover for other team members. Therefore, you may have a different task than the one you had in the training session and have the opportunity to master another task.*" The Eiffel model also included elements in which no team member had been trained and that were not assigned to any team member in particular. Thus, after the members completed their individual parts, they had to connect them and develop additional parts in order to complete the model.

Coordination was manipulated by varying how much team members shared a common language, which should have affected how easily team members worked as a collective unit. To manipulate coordination, three versions of the instructions were created. The versions were identical except for the names given to 20 out of the 30 K'NEX parts. We chose 20 parts with ambiguous shapes because parts with ambiguous shapes lent themselves to being called different names. For example, a part that was labeled a snowflake in one version was labeled a spider or a sunburst in the other version. Similarly, a part that was labeled a bird footprint in one version was labeled a leaf in another and a snowshoe in the third version (see Appendix B for more examples). In the shared language condition, all team members received instructions that contained the same names for the 20 parts, which should have made it easier for team members to collaborate and work as a collective unit. In the unshared language condition, each team member received instructions with different names for the 20 parts, which should have made it more difficult for team members to work together. A memory test was administrated during the training period to assure that the participants learned the names of the K'NEX parts.

Similar to most team tasks, assembling the K'NEX model required a mix of individual and joint activities, and teams could vary with respect to when they decided to accomplish those activities. Communication and collaboration was encouraged throughout the session by randomly assigning the K'NEX parts across team members. Thus, team members had to communicate with each other to obtain the parts they needed for their sub assemblies. So even if team members decided to focus on their individual work first, they still had to communicate with each other, and they communicated with part names to obtain the various parts they needed from their teammates.

Our experimental conditions manipulate knowledge utilization and coordination. We recognize, however, there is more to knowledge utilization than simply matching expertise and more to effective coordination than sharing a language. Knowledge utilization could vary with a number of team-based dynamics, such as competition among team members and individualistic norms (Hinds and Pfeffer, 2003). Effective coordination also has multiple sources, including the demographic composition of the team. More importantly, the observed levels of knowledge utilization and coordination could moderate how our experimental conditions influence team performance. Any positive effect that sharing a language has on team performance, for example, could be even more pronounced when coordination is accomplished through multiple channels. Thus, in addition to manipulating the productivity factors, we measured specialization (which is a more general form of knowledge utilization) and coordination using scales developed by Lewis (2003): specialization (e.g., Each team member has specialized knowledge of some aspect of our project) ($\alpha = 0.83$) and coordination (e.g., Our team worked together in a well-coordinated fashion) ($\alpha = 0.76$). The specialization and coordination scales exhibited sufficient interrater agreement (median $r_{wg} = 0.79$ and 0.86, respectively) (James, 1982) and intraclass correlations were adequate enough (ICC(1) = 0.09 and 0.37 and ICC(2) = 0.23 and 0.64, respectively (Bliese, 2000)) to justify aggregation of the responses to the team level.[2] The level of specialization observed on a team is the mean of the specialization items from the Lewis scale and the level of coordination is the mean of the coordination items.

Results

2 We used intra-class correlations (ICCs), to assess whether there was sufficient between-group variance to warrant team-level modeling (Bliese, 2000). ICC(1) represents the relative proportion of between-group vs. total variance, whereas ICC(2) represents the reliability of the group average perceptions. While Rwg is calculated within each group based only on the observed variance within that group, ICC is calculated using within-group and between-group variance. Therefore, the relatively low ICC values with high Rwg values may result from small between-group variance. The lower between-group variance should attenuate our results thereby making them conservative.

Manipulation Checks

To examine the effectiveness of our manipulations, we measured the absence of a shared language with four items ("My partners and I, at times, seemed to be using a different language", "My partners and I used different terms to describe the K'NEX parts used in to assemble the models", "At times, my partners and I didn't understand what each other meant when we referred to the K'NEX parts", and "I had difficult time understanding what my partners are trying to say"). The four items loaded on a single factor and so were averaged to define an unshared language variable ($\alpha = 0.91$). The unshared language variable was regressed on the two language conditions. The results indicate that teams in the shared language condition were less likely to report they did not share a language (b = -2.04, t = -15.44,, p < .001) than teams in the unshared language condition. We also measured the extent to which team members felt they were provided with an opportunity to utilize knowledge they acquired in the training phase during the performance phase with the following items ("In the second stage, I had a similar task that I had in the first stage", "The experience I gained in the first stage was very relevant to the task I did in the second stage of the study", "In the second stage of the study, I had the chance to gain experience on new aspects of the task that I didn't work on in the first stage of the study"). The first two items loaded on a single factor, while the third item did not, and so we measured perceived knowledge utilization with the average of the first two items. Perceived knowledge utilization ($\alpha = 0.69$) was regressed on the two knowledge utilization conditions. The results indicate that teams in the high knowledge utilization condition were more likely to perceive that they utilized their knowledge (b = 1.25, t = 10.25, p < .001) than teams in the low knowledge utilization condition. These findings suggest that we effectively manipulated shared language and knowledge utilization.

Team Performance: Completion Times

Our performance metric is the amount of time it took team members to build the K'NEX Eiffel Tower model. Since teams in Israel were given more time to build the model, completion times were transformed within locations to facilitate comparisons between teams from different locations.[3] Completion times were regressed on the experimental conditions. To adjust our estimates for unmeasured differences between the two locations, we included in our regression equation an indicator variable that was set equal to one if the data were collected in the US and equal to zero otherwise. The regression also included a control for the number of mistakes in the team's final model (e.g., missing parts, incorrect

[3] Completion times from different locations were made more comparable (i.e., the same scale) by subtracting the minimum completion time observed within a location from each completion time and dividing that quantity by the difference between the maximum and minimum completion times within each location.

connection of parts), which indirectly controlled for the quality of their effort.[4] Finally, 16 of the 185 teams did not finish building the model before time expired. While we reach the same substantive conclusions if we ignore these teams, we prefer to condition our estimates on the likelihood of completion. To condition our estimates on completion, we included an indicator variable that was set equal to one if the team completed the model and remained equal to zero otherwise. We have also estimated more sophisticated models to condition our estimates on the likelihood of completion (e.g., a hazard model and a Heckman selection model). Results from these models and from ordinary least squares regression (OLS) lead to the same substantive conclusions. We focus on the OLS results below.

Descriptive statistics for our variables, including correlations, can be found in Table 2. Specialization and coordination were logged transformed to reduce skew. Results from the regression analysis can be round in Table 3. The coefficients in model 1 indicate that teams in the high knowledge utilization and shared language condition took less time to assemble the model. The coefficient for the interaction between the two productivity variables was negative and significant. While teams with both productivity factors took the least amount of time, it is interesting to note that neither productivity factor alone had an effect on completion times. The main effect for knowledge utilization and the main effect for sharing a language were not significantly different from zero. The joint contributions did matter.

The estimated completion times across the conditions are illustrated in Table 4. If we just consider teams that shared a language, high knowledge utilization teams took less time to build the model than low knowledge utilization teams ($\Delta = -.138$, se = .052, $p < .05$). But when we consider teams that did not share a language, low and high knowledge utilization teams completed the task in the same amount of time ($\Delta = .030$, se = .047, $p = .520$). A similar pattern emerged for knowledge utilization. When we focus on teams with high knowledge utilization and compare the completion times for teams from the two language conditions, teams in the shared language condition took less time ($\Delta = -.106$, se = .052, $p < .05$). But when we focus on teams with low knowledge utilization, sharing a language did not have an effect on completion times ($\Delta = .062$, se = .048, $p = .196$).

The results provide support for hypothesis 1 and hypothesis 2. Although we did not expect for each productivity factor to have no effect on team performance when the other factor was low, the results are consistent with our predictions. Finally, our teams were asked to perform a task high in process interdependence and low in output interdependence so we expected for teams that shared a language but were low on knowledge utilization to do better than teams that were high on knowledge utilization but did not share a language. We did not find support for the third hypothesis ($\Delta = -.031$, se = .052, $p = .529$) on model 1.

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[4] We do not have number of mistakes for three teams so we have excluded those teams from our analysis.

In model 2 of Table 3, we let the observed levels of specialization and coordination moderate the associations between our experimental conditions and team performance. With two experimental conditions and two moderators, we estimated a model with a four-way interaction term. The estimates from model 2 indicate that our knowledge utilization effect varied with specialization, coordination, and the interaction between specialization and coordination. We re-estimated model 2, and only included higher order interactions terms if they were statistically significant. The coefficients are in model 3 of Table 3. Interpreting interaction terms can be difficult. To facilitate interpretation, we focus on estimated completion times for the experimental conditions at specific levels of specialization and coordination. We focus in particular on when specialization and coordination are either one standard deviation below or one standard deviation above their respective means (Aiken and West, 1991).

Table 5 contains estimated completion times for our experimental conditions at specific values of specialization and coordination. The completion time in the first cell is for low knowledge utilization and unshared language teams when specialization and coordination are both one standard deviation below their respective means. The time in the second cell is for low knowledge utilization and shared language teams when specialization is one standard deviation below its mean but coordination is one standard deviation above its mean. The time in the third cell is for high knowledge utilization and unshared language teams when specialization is one standard deviation above its mean but coordination is one standard deviation below its mean. The completion time in the fourth cell is for high knowledge utilization and shared language teams when specialization and coordination are both one standard deviation above their respective means. Thus, the estimated completion times in Table 5 illustrate the effects for the experimental conditions when the observed levels of specialization and coordination parallel the levels implied by the experimental conditions.

The estimates in Table 5 indicate that the fastest teams shared a language and utilized their knowledge. However, the slowest teams were not teams that did not utilize their knowledge and did not coordinate their behavior. The slowest teams were teams that were unable to coordinate their work but managed to utilize their specialized knowledge. This outcome illustrates the potential failure mode we identified for knowledge utilization. When team members are unable to coordinate, utilizing specialized knowledge can undermine team performance. Overall, the estimates provide strong support for our predictions. The estimated completion times indicate that effective coordination reduced completion times, especially when team members utilized their knowledge. Teams in cell 2 were faster than teams in cell 1 ($\Delta = -.152$, se = .065, $p < .05$) and teams in cell 4 were faster than teams in cell 3 ($\Delta = -.474$, se = .089, $p < .05$). And the performance improvement associated with an increase in coordination was much larger when knowledge utilization was high versus when knowledge utilization was low (-.474/-.152 = 3.103, se = 1.402, $p < .05$). The estimates also indicate that utilizing knowledge was most beneficial when team members had a capacity for collective action. Teams in cell 4 were faster than teams in cell 2 (Δ = -.134, se = .066, $p < .05$). And knowledge utilization without effective coordination undermined team performance. Teams in cell 3 were slower than teams in cell 1 (Δ = .187, se = .063, $p < .05$). Finally, when we compare off diagonal teams, teams that coordinated effectively but did not utilize specialized knowledge did better than teams that did not coordinate effectively but utilized their knowledge (Δ = .339, se = .070, $p < .05$). Thus, when we account for observed levels of specialization and coordination, we find support for Hypothesis 3 as well as for Hypotheses 1 and 2.

Robustness Checks

We conducted additional analysis to examine the robustness of our empirical results. For example, in our regression model, we controlled for the number of mistakes in a team's final model (e.g., missing parts, incorrect connection of parts). One could argue that like completion time, number of mistakes is a dependent variable. To examine this issue, we combined completion time and the number of mistakes a team made into a composite performance variable. We defined team performance as (completion speed)/(1 + relative number of mistakes). We subtracted the completion time for a specific team from the maximum observed completion time, which turned our completion time data into an indicator of completion speed. We divided completion speed by 1 + the relative number of mistakes a team made. Dividing by the number of mistakes a team made introduces a time penalty for mistakes. Relative number of mistakes is the number of mistakes made by a team divided by the maximum number of mistakes made by any team. We considered dividing by the number of mistakes a team made but the time penalty seemed too severe. For example, if we divided by the number of mistakes, the first mistake a team made would cut the team's completion speed in half and the next mistake would reduce the team's completion speed by 67 percent. Dividing by the relative number of mistakes seemed more appropriate. For example, if a team commits half as many mistakes as the team with the most mistakes, its completion speed is cut by approximately 33 percent while the team that commits the most mistakes has its completion speed cut by 50 percent. If we replace completion time with the composite performance variable described above and re-estimate model 3 in Table 3, we again find support for all three predictions. The results are in Table 6 column 1. While we believe it is important to include errors in our analysis, if we do not introduce a time penalty for errors, which is equivalent to not controlling for errors, we again find support for all three predictions but the empirical evidence in support of our first hypothesis is only marginally significant.

We let the observed levels of specialization and coordination moderate how much our experimental conditions contributed to team performance and we did so because we believe it is a mistake to reduce our key constructs to our experimental conditions alone. And yet, if our experimental conditions were effective, the level of specialization observed on a team should be higher when knowledge utilization is high and the level of coordination should be higher when team members share a language. In other words, the regression results we have presented, thus far, have assumed specialization and coordination are exogenous when they are likely to be endogenous. To adjust our estimates for this dynamic, we estimated a structural equation model (SEM) that included the predictors from model 3 in table 3 on completion time and that also estimated the extent to which the experimental conditions affected the observed levels of specialization and coordination. The SEM results indicate that the knowledge utilization condition had a positive effect on specialization ($b = .123$, $se = .022$, $p < .05$) and the shared language condition had a positive effect on coordination ($b = .028$, $se = .016$, $p < .10$). The estimates are positive and significant, although the association between sharing a language and coordination is only marginally significant. The estimates illustrate that there is more to specialization than knowledge utilization and more to coordination than sharing a language. Moreover, when specialization and coordination are endogenous, the predictors in model 3 have virtually the same effect on completion times. The results are in Table 6 column 2. Please note that the dependent variable in column 2 and the remaining columns of Table 6 is completion time and not the composite performance variable.

We collected data at two universities. We combined the two samples and introduced a control variable to adjust our estimates of completion time for any potential differences between the two settings. In addition to affecting completion times directly, where we collected the data could have affected the association between other predictors in our model and completion time. For example, subjects in the US were more familiar with the K'NEX objects, which could have affected how much subjects were able to utilize the knowledge they acquired during the training stage and familiarity also could have affected how well team members worked with each other while building the tower. We checked for these kinds of differences between the two samples by allowing the coefficients in model 3 of Table 3 to vary by location. When we do, we do not observe any significant interactions with our location variable. Moreover, when we conduct an omnibus test for all interactions, the test is not significant ($F(13, 154) = 0.99$, $p = .46$). Where we collected the data does not appear to have affected how the predictors in our model affected completion times. Moreover, when we consider the completion times after making these adjustments, we find support for our predictions. The results are in Table 6 columns 3 and 4. There is only one regression equation for the results in columns 3 and 4. The effects in column 3 are the main effects. We used the LINCOM command in STATA to combine the main effects and interactions to create the coefficients for the US sample.

Finally, we believe the empirical results we have observed are contingent upon the task we asked team members to perform. With respect to the Eiffel Tower task, we assumed output interdependence was low while process interdependence was high. We assumed output interdependence was low because team members knew what they were producing (i.e., everyone was familiar with the Eiffel Tower) and there were a limited number of ways to combine their specialized knowledge and expertise to build the tower. We assumed process interdependence was high. Team members could organize their activities in a variety of ways and successfully assembling the tower required coordination across people performing different activities. To examine the appropriateness of these assumptions, we analyzed how much time team members spent working together versus alone . Performing our task required that team members spend time working alone and working together. When we collected data in Israel, we measured how much time team members worked alone and how much time they worked together. We did not collect this data for US teams. We did, however, videotape 58 teams and we used those videos to measure the amount of time team members worked together and the amount of time they worked alone. If process interdependence is high and output interdependence is low, team members should spend significantly more time working together. To facilitate comparisons between teams that took different amounts of time to complete the task, we turned the two time variables into proportions. We found that team members spent significantly more of their time working together than alone (72% together vs. 28% alone, $t = 32.6$, $df = 152$, $p < .001$). While not definitive, the empirical results are consistent with our assumptions.

Discussion and Conclusion

Our research was motivated by a simple observation. A large number of studies have documented the positive effect that knowledge utilization and coordination can have on team performance. The empirical approaches adopted by prior researchers have illuminated the performance of some teams in Table 1 but have obscured the performance of other teams. In particular, while we know a great deal about the relative performance of teams that either possess or lack both productivity factors, we know less about the performance of teams when a team is high on one productivity factor. We believe there is a great deal to learn by studying these off diagonal teams. For example, consider a team leader or manager who would like to improve a team's performance. The best teams utilize knowledge and collaborate, but getting teams to do both initially can be problematic. Developing specialized work roles and responsibilities can make it more difficult for team members to coordinate their behavior, while too much attention to effective collaboration can detract from team members' ability to develop specialized knowledge and expertise. The team leader is presented with a choice that could trade off the key two elements of team performance.

Our research findings highlight additional challenges facing the manager. In particular, we found that the value of each productivity factor was contingent upon the level of the corresponding factor. When the two productivity factors are multiplicative and not simply additive, an increase in knowledge utilization could not only undermine coordination, the decline in a capacity for collective action could render the current level of knowledge utilization less beneficial for team performance. Similarly, an increase in coordination could undermine the accumulation of specialized knowledge and also reduce how much knowledge utilization improves team performance.

If a team leader decides to focus on the off-diagonal cells, he or she will discover these choices represent their own set of challenges. In particular, we presented argument and evidence indicating that knowledge utilization and coordination have potential failure modes. We know that superior teams select and implement the best solutions to a given problem. But we also know that knowledge experts in one domain are likely to define the team problem and corresponding solution differently from individuals who are expert in other domains. If the team is composed of knowledge experts who are unable to communicate the performance implications of their individual choices when considering solutions to the team's problem, each one is more likely to focus on the best ideas and solutions from his or her perspective. Consequently, the team is unlikely to converge on a good solution for the team. And even if team members manage to converge on a good solution, they are likely to waste considerable time and energy along the way. The point is effective knowledge utilization can introduce process loss and unless knowledge utilization also introduces benefits that offset process loss, an increase in knowledge utilization could undermine team performance.

While the failure mode for experts who cannot coordinate is too many solutions, the failure mode for non-experts who can coordinate is too few solutions. When non-experts can coordinate their behavior, instead of continuing to search for better team solutions, they are more likely to converge on a solution that meets minimum requirements, even when superior alternatives are within their reach. If there is something to gain from continued search and exploration, terminating search too soon could undermine team performance. Thus, teams in the off-diagonal cells have distinct productivity failure modes and therefore each presents a different challenge.

We maintain the relative attractiveness of the off diagonal cells depends on the degree of interdependence characterizing a team's task. While interdependence is often used to describe workflows and activities, it can also be used to describe a team's solution space and the output it produces. When a team's solution space is characterized by a high degree of output interdependence, the solution space is more rugged and individual search and exploration increase the odds superior team solutions will be discovered. Creativity and more intellectual tasks are examples of tasks that have a high degree of output interdependence. Process interdependence is higher when team members are reciprocally interdependent, for example, a form of interdependence that requires more intense coordination than sequential or pooled interdependence (Thompson, 1967). A hospital surgical team is an example of a team high in reciprocal interdependence. The activities of one team member affect the activities of another whose activities in turn affect the first team member. A boat crew is another example of a team with reciprocal interdependence. Output and process interdependence determine the relative attractiveness of the off diagonal cells because they affect how much knowledge utilization and coordination contribute to team performance. For example, knowledge utilization is important for a brainstorming task where the goal is to generate as many ideas as possible (Taylor, Berry, and Block 1958). When process interdependence is low and output interdependence is high, knowledge utilization has a large effect on team performance, and coordination has a smaller effect. Under this condition, any potential process loss search introduces should be less problematic for team performance. Ending search prematurely would be more problematic than failing to coordinate. Therefore, when output interdependence is high and process interdependence is low, high knowledge utilization and low coordination teams should do better than low knowledge utilization and high coordination teams. However, when output interdependence is low and process interdependence is high, high knowledge utilization and low coordination teams should do worse than low knowledge utilization and high coordination teams. Given the degree of output and process interdependence characterizing our task, we expected for teams composed of non-experts that could coordinate their behavior to do better than teams composed of experts who could not coordinate. We found support for this prediction. But it is important to emphasize that we believe that the relative performance of the off diagonal teams would be reversed if the task was characterized by a high degree of output and a low degree of process interdependence.

While we only tested one part of our argument, we find some comfort in the fact that our predictions parallel results found in research describing the association between demographic diversity and team performance which highlights the importance of the team's task in shaping the overall association between demographic diversity and team performance (O'Reilly III and Phillips, 1999). An increase in demographic diversity has mixed implications for team performance because, on the one hand, the increase in demographic diversity increases the amount of non-redundant (i.e., specialized) knowledge available on the team but, on the other hand, the increase also can reduce the ability of team members to collaborate and work collectively. When the team's performance outcome requires creative problem solving and innovation, the benefits that diversity can introduce often outweigh the potential downside, and thereby result in an overall positive association between demographic diversity and team performance. We believe more research is needed to determine the extent to which features of the task affect how knowledge utilization and coordination shape team performance alone and when combined with each other.

Despite this limitation, our research findings have important theoretical and practical implications. Concerning theory, previous research has highlighted the importance of high levels of coordination and knowledge utilization for superior team performance. Prior research has emphasized the superiority of teams that are high on knowledge utilization and coordination when compared to teams that are low on both dimensions. If we return to Table 1, the best teams are in cell 4 and the worst teams occupy cell 1. Teams in cell 2 and cell 3 are expected to fall somewhere in between the best and worst teams. This assumption is implicit in empirical research (Lewis, 2003; Gino, Argote, Miron-Spektor, and Todorova, 2010). For example, scholars who sum knowledge utilization and coordination to define a TMS scale assume that the two factors contribute to performance equally in an additive form. The underlying model assumes that the two factors contribute to team performance equally and that a low value on one factor can be offset by a high value on the other factor. Our research findings call this assumption into question. Our research findings suggest that instead of summing knowledge utilization and coordination to define the level of TMS on a team, we need to think carefully about how knowledge utilization and coordination combine to create a transactive memory system and shape team performance.

In addition to research on distributed cognition, our research has implications for other areas such as organizational design. Interest in organizational design was central to the field of organizational theory in its early days but then waned. Organization design has reemerged as an exciting research topic in recent years (Dunbar and Starbuck, 2006). A key concept in this area is interdependence (MacCormack et al., 2012: 1311). The degree of interdependence between organizational units can affect a number of organizational processes and outcomes. Indeed, recent research has shown that the level of interdependence in an organization is often reflected in the products it produces (MacCormack et al., 2012). Interdependence in the broader market context is relevant for firm performance. The level of interdependence characterizing products in a product category has important implications for incumbent firms and entrepreneurs operating in an industry (Baldwin and Clark, 2000).

Scholars who study organizational design have developed and tested their frameworks using a variety of techniques. For example, researchers have productively used simulations (Ethiraj and Levinthal, 2004; Carroll, Gormely, Bilardo, Burton, and Woodman, 2006; Fang, Lee and Schilling, 2010), analytic models (Kretschmer and Puranam, 2008) and qualitative methods (Bechky, 2006) to develop theory about organizational design. The resulting frameworks have important implications for managers (i.e., organizational architects) who are interested in designing organizations to improve organizational performance. For example, the research describes how an architect could manipulate the level of interdependence characterizing a team's solution space to increase the odds of more radical innovations (Levinthal and Warglien, 1999) or how the architect could manipulate how members of an organization experience interdependent workflows, processes, and activities. Indeed, different organizational design decisions can either promote or limit the required level of feedback-based (i.e., emergent) coordination between individuals performing different parts of an interdependent task (Puranam et al., 2012). We believe these frameworks are important and can be productively complemented by theory building and testing in the experimental laboratory. For example, our framework highlights how the level of output and process interdependence characterizing a task can shape the conditions under which a specific productivity factor should be avoided because it could ultimately undermine team performance.

We investigated the effects of knowledge utilization and coordination on team performance in the controlled setting of the laboratory because the laboratory enabled us to examine the effect of one productivity factor at low and high levels of the other. Reviews of studies in the laboratory and the field of conceptually similar variables have concluded that they generally yield similar results (Anderson, Lindsay, and Bushman, 1999). Examining the relationship between knowledge utilization and coordination in other contexts would be useful in establishing the generalizability of our results and identifying boundary conditions for the relationship between knowledge utilization and coordination that we found here.

Our results have implications for managerial practice. We found that an increase in knowledge utilization or coordination was most beneficial when the corresponding productivity factor was present. And we also found that an increase in knowledge utilization could even undermine team performance when coordination was low. Our framework predicts a similar failure mode for coordination when task complexity is high. We apply these findings to a boat crew team to illustrate the practical implications of our results. We begin by considering the highest performing crew. The fastest boat contains the most skilled and strongest individuals who row in concert. Boat speed increases when each individual utilizes his or her knowledge and skills effectively and when his or her actions are synchronized with the actions of other crew members. A crew high in knowledge utilization would assign members to the positions for which they are most qualified. For example, the coxswain has to know how to steer the boat, coach the crew, and motivate team members. The most technically proficient rowers are typically placed at either end of the boat while the physically strongest are placed in the middle. The performance of the boat crew also depends on coordinating the activities of individual members. Coordination of team members' activities is accomplished through rules and routines developed during practice and through communication among crew members during task performance. Crew members need to row at the same rate and in the same direction. Members need to be able to adjust to unexpected developments on the water. When crew members are assigned to positions that utilize their knowledge and skills and when crew members coordinate their activities, the performance of the crew is enhanced.

Consider a team of experts who are unable to coordinate. Each expert focuses his or her attention on the best solutions and ideas from his or her domain. Because the experts do not have the capacity to coordinate, they are not able to consider the implications of their individual actions for overall team performance. When a team is composed of experts who do not coordinate, team members can experience unproductive task-based conflict as experts "fight" over the direction the team should pursue. On a crew team, this lack of coordination would manifest itself in members pulling in different directions with differing degrees of force. Their activities would not fit together and the performance of the team would suffer. A manager of a team with these problems would need to provide opportunities for team members to learn how to coordinate. Training team members together and providing them opportunities to work together have been shown to be effective in enhancing coordination (Liang et al., 1995). Providing a shared vocabulary of terms (Weber and Camerer, 2003) facilitates communication, which would be especially valuable in uncertain conditions, and enables coordination. Managers need to build in the social glue that enables team members to connect the pieces of their work.

Our results also indicate that being high on coordination and low on knowledge utilization can result in sub par performance. Many studies have shown that although teams perform better than the average of individuals, teams are rarely as good as the best individual (see Hill, 1982 for a review). The performance of teams that emphasize coordination will fall short of the team's potential performance. These teams are more likely to go with a satisfactory solution than a solution that optimizes the use of their members' knowledge. Thus, an emphasis on coordination without a corresponding emphasis on the recognition of knowledge and skills can have a negative effect on team performance. For example, a boat crew lacking members who can steer in challenging conditions is likely to encounter problems even if members are well coordinated. Managers of such teams need to provide opportunities for individuals to develop and hone their individual skills. Research has shown that learning by doing is less successful when individuals have to coordinate their behavior with colleagues who are also learning than when they do not have to coordinate their activities (Lounamaa and March, 1987; Levinthal and March, 1993). Individuals are more likely to learn when interdependent tasks are buffered or when coordination is punctuated over time.

In closing, our results indicate that the effect of knowledge utilization on team performance is more positive when teams are able to coordinate their activities. And the effect of coordination on team performance is more positive when team members are able to utilize their specialized knowledge. Our research highlights challenges that can arise in the off diagonal cells in Table 1 and the steps a manager should take to avoid those risks and overcome problematic performance. Thus, ideally, a team should promote both coordination and knowledge utilization. If a manager has to pick between the two off diagonal cells due to resource constraints, our findings suggest that if the task is low in output interdependence and high in process interdependence, optimizing coordination at the expense of knowledge utilization is superior to optimizing knowledge utilization at the expense of coordination. If a team can focus on only one of the factors, our results indicate that when output interdependence is low and process interdependence is high, focusing on coordination is more valuable than focusing on knowledge utilization. Future research is needed to determine how knowledge utilization and coordination interact to determine team performance as task characteristics change.

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Table 1	Low coordination	High coordination
Low knowledge utilization	1	2
High knowledge utilization	3	4

Table: Descriptive Statistics

	Mean	Std. Dev.	Completion Time	Matched	Shared	Specialization	Coordination	US	Complete	0 Mistakes	1-5 Mistakes	6-10 Mistakes	10+ Mistakes
Completion Time	.591	.283	1										
Matched Expertise	.467	.500	-.106	1									
Shared Language	.521	.500	-.079	.036	1								
Specialization	1.628	.164	.017	.376	.061	1							
Coordination	1.889	.112	-.529	-.037	.128	.123	1						
US	.472	.500	.168	-.069	-.019	-.225	.033	1					
Complete	.912	.283	-.447	-.020	.091	-.009	.500	.060	1				
0 Mistakes	.620	.486	-.188	.005	-.045	-.081	.175	.285	.197	1			
1-5 Mistakes	.241	.429	-.058	-.039	.103	.094	.039	-.251	.039	-.722	1		
6-10 Mistakes	.032	.179	.023	.135	-.008	.132	-.045	-.113	.057	-.236	-.104	1	
10+ Mistakes	.104	.306	.367	-.031	-.069	-.080	-.305	-.035	-.401	-.436	-.192	-.063	1

Table 3: Completion Times			
	Model 1	Model 2	Model 3
Constant	.822 (0.49)**	2.469 (3.597)	5.724 (3.063)*
Matched expertise (Matched)	.030 (.047)	-10.511 (4.468)**	-12.035 (4.127)**
Shared language (Shared)	.062 (.048)	6.650 (6.516)	.0699 (.044)
Matched X Shared	-.169 (.070)**	3.893 (12.424)	-.161 (.065)**
Specialization		-.147(2.325)	-2.216 (2.015)
Matched X Specialization		6.764 (2.928)	7.921 (2.673)**
Shared X Specialization		-4.223 (4.146)	—
Matched X Shared X Specialization		-1.710 (7.493)	—
Coordination		-1.135 (1.942)	-2.963 (1.627)*
Matched X Coordination		5.619 (2.417)**	6.360 (2.226)**
Shared X Coordination		-3.653 (3.438)	—
Matched X Shared X Coordination		-2.142 (6.514)	—
Specialization X Coordination		.189 (1.255)	1.350 (1.072)
Matched X Specialization X Coordination		-3.608 (1.573)**	-4.188 (1.434)**
Shared X Specialization X Coordination		2.343 (2.188)	—
Matched X Shared X Specialization X Coordination		.894 (3.931)	—
1-5 Mistakes	.056 (.046)	.035 (.043)	.042 (.042)
6-10 Mistakes	.182 (.106)*	.086 (.091)	.112 (.084)
10+ Mistakes	.222 (.045)**	.217 (.044)**	.214 (.044)**
US	.129 (.038)**	.126 (.039)**	.137 (.036)**
Complete	-.371 (.037)**	-.177 (.057)**	-.182 (.053) **
Observations	182	182	182
R-Squared	.325	.485	.476

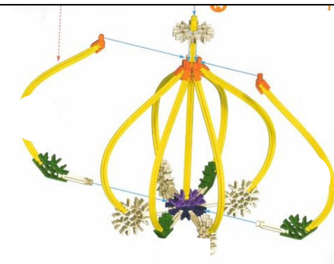
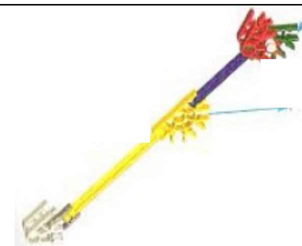
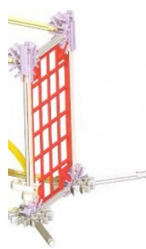
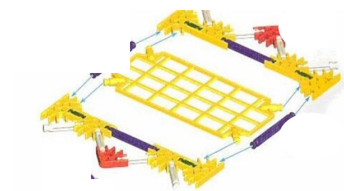
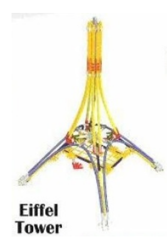
Coefficients are from ordinary least squares regression. Their standard errors are in parentheses.
* = p < .10, ** = p < .05

Table 4	Unshared Language	Shared Language	
Low Knowledge Utilization	.587 (1)	.650 (2)	Δ = .062 (.048), p = .196
High Knowledge Utilization	.618 (3)	.511 (4)	Δ = -.106 (.052), p < .05
	Δ = .030 (.047), p = .520	Δ = -.138 (.052), p < .05	
When we compare teams in cell 3 to teams in cell 2, Δ = −.031 (.052), p = .529			

Table 5	Unshared Language (Coordination = mean – sd)	Shared Language (Coordination = mean + sd)	
Low Knowledge Utilization (Specialization = mean – sd)	.660 (1)	.507 (2)	Δ = -.152 (.065), p < .05
High Knowledge Utilization (Specialization = mean + sd)	.847 (3)	.373 (4)	Δ = -.474 (.089), p < .05
	Δ = .187 (.063), p < .05	Δ = -.134 (.066), p < .05	
When we compare teams in cell 3 to teams in cell 2, Δ = .339 (.070), p < .05			

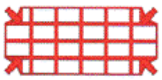
Table 6: Robustness Checks				
	Speed/Mistakes (1)	Endogenous Moderators (2)	Israel (3)	US (4)
Constant	-3.782 (2.124)	5.724 (3.467)*	5.762 (3.214)*	5.717 (5.162)
Matched expertise (Matched)	8.670 (4.094)**	-12.035 (5.247)**	-9.493 (4.942)*	-13.669 (6.960)*
Shared language (Shared)	-.057 (.045)	.069 (.042)*	.105 (.067)	.054 (.064)
Matched X Shared	.139 (.068)**	-.161 (.062)**	-.199 (.098)**	-.154 (.097)
Specialization	1.412 (2.027)	-2.216 (2.213)	-1.730 (2.211)	-2.612 (3.257)
Matched X Specialization	-5.695 (2.632)**	7.921 (3.289)**	5.545 (3.317)*	9.869 (4.352)**
Shared X Specialization	___	—	—	—
Matched X Shared X Specialization	___	—	—	—
Coordination	2.429 (1.663)	-2.963 (1.826)*	-3.019 (1.734)*	-2.867 (2.728)
Matched X Coordination	-4.635 (2.226)**	6.360 (2.789)**	5.013 (2.681)*	7.340 (3.823)*
Shared X Coordination	—	—	—	—
Matched X Shared X Coordination	—	—	—	—
Specialization X Coordination	-.938 (1.080)	1.350 (1.167)	1.128 (1.185)	1.538 (1.740)
Matched X Specialization X Coordination	3.049 (1.421)**	-4.188 (1.742)**	-2.937 (1.780)*	-5.276 (2.389)**
Shared X Specialization X Coordination	—	—	—	—
Matched X Shared X Specialization X Coordination	—	—	—	—
1-5 Mistakes	__	.042 (.038)	.052 (.054)	.000 (.080)
6-10 Mistakes	__	.112 (.089)	.141 (.098)	-.037 (.073)
10+ Mistakes	__	.214 (.057)**	.190 (.077)**	.221 (.070)**
US	-.126 (.034)**	.137 (.033)**	__	__
Complete	.239 (.052)**	-.182 (.068)**	-.236 (.074) **	-.161 (.108)
Observations	182	182	182	__
R-Squared	.421	__	.504	__
Log likelihood		255.639		
Regression coefficients with their standard errors are in parentheses. * = p < .10, ** = p < .05				

Appendix A

Individual Task	Parts assembled in the training stage	Parts assembled in the performance stage
Role A		 
Role B		
Role C		
The Complete Model		

Appendix B

Examples of the Three Lexicons

K’nex Part	Version A	Version B	Version C
	Grid	Lattice	Panel
	Snowflake	Sunburst	Spider
	Half snowflake	Half sunburst	Setting Sun
	Ladder	Bridge	Tracks
	Leaf	Quarter snowshoe	Bird footprint
	Pulley	Half bridge	Half trak
	Arch	White U	Curve
	Pinch connector	Pinch connector	Pinch connector
	Angled pinch connector	Angled pinch connector	Angled Pinch connector
	Hole	Ring	Circle