From Thought Diversity to Innovation in R&D Teams: The Effects of Collaborative Learning, Psychological Safety, and Shared Mindset [1]

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Abstract

Managers have become increasingly aware of the need to leverage diversity in their organizations as a means to increase innovation. At the same time the multiple and often contradictory team dynamics that arise in diverse teams present organizations with major challenges. The goal of this study was to develop an understanding of how diversity of thought among the members of innovation teams affects team dynamics and innovation outcomes. We surveyed 28 teams from 14 organizations to evaluate the innovativeness of their behaviors and work, their team dynamics, and their ways of thinking. For each team, separate surveys were administered to team members and stakeholders. We found that functional diversity promoted innovation but led to poor team dynamics. Teams of sequential thinkers reported less collaborative learning and innovation, while teams of cross-disciplinary thinkers reported more collaborative learning and innovation. Based on our findings, strategies to foster a team's innovation include increasing its functional diversity, reducing the team's tendency to think sequentially and increasing its tendency to engage in cross-disciplinary thinking. At the same time, team members should be encouraged to learn from each other and to voice divergent opinions, but discouraged from relying on a single, shared mindset (i.e., a shared interpretive scheme).

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Diversity in R&D innovation teams is unavoidable. The growing needs for scientific discoveries that bridge fields and reduce time to market have led to an increasing reliance on cross-functional work, cross-disciplinary work, and open innovation. In addition changes in the scientific and technical workforce have brought people together who are not always used to working with each other. In these circumstances, companies face the challenge of developing breakthrough innovation within teams whose members often see the world through the lens of their own areas of expertise, knowledge, or organizational affiliation, and who bring to the team different problem solving approaches. Current research has identified effects of demographic diversity (e.g., gender, race/ethnicity, age, tenure) and the mechanisms by which it works within groups. However, much less is known about how the diversity of thought in teams (e.g., diversity in perspectives and in approaches to problem solving) affects team dynamics and innovation.

In this paper we report on a study of 28 innovation project teams across 14 companies and 9 industries. The goal of this study was to understand how a team's thought diversity affects its interpersonal team dynamics (i.e., collaborative learning, psychological safety, a shared mindset) and innovation outcomes. We draw on Scott Page's (2007) work and measure a team's thought diversity by the variety of perspectives present on the team (e.g., the variety of educational and of functional perspectives) and by the team's reliance on two approaches to problem solving: sequential thinking and cross-disciplinary thinking. Our results provide some guidance on composing or re-composing teams to facilitate innovation. At the same time, our results draw attention to how thought diversity may inhibit interpersonal team dynamics that foster innovation or exacerbate team dynamics that stifle innovation.

THOUGHT DIVERSITY, TEAM DYNAMICS, AND INNOVATION OUTCOMES

Thought diversity is best described as a double-edged sword for innovation. On one hand, diversity provides the resources (knowledge, expertise, problem solving approaches) that, combined in novel ways, produce innovation. Thought diversity in a team (diversity in perspectives and in approaches to problem solving) helps members maintain multiple sets of assumptions as the team considers a problem, which in turn increases the number of alternatives that members consider. Teams that consider more alternatives produce more innovative outcomes. Thought diversity is especially beneficial in groups where minority views can be expressed and get due consideration. On the other hand, diversity carries within itself the seeds of conflict. When team members have different values, priorities, communication styles, and contradictory organizational incentives, they identify less with the team, feel less comfortable voicing divergent opinions, and are more likely to develop negative feelings toward other team members. In order to understand each other and hence leverage their resources, team members with different backgrounds and perspectives need to develop a shared mindset, that is, create a shared way of seeing and interpreting reality. Paradoxically, however, when a shared mindset develops, team members may be less likely to share unique points of views and knowledge that contradict the shared mindset in the group. Hence the advantage of diversity may be lost in team members' efforts to create a shared mindset.

The goal of the present study is to evaluate how innovation emerges from diverse teams, and how team diversity affects critical team dynamics for innovation: collaborative learning (i.e., taking time to learn together and adjust to each other), psychological safety (i.e., team members' belief that expressing oneself will not lead to negative evaluation or criticism from others) and shared mindset (i.e., agreement on how to value, interpret, and use information). Our paper is organized as follows: we start by defining the concepts in our model that are of interest for the

questions at hand. Then, we outline our rationale for the expected relationships among the concepts in our model. Next, we provide information about the study's methodology. Then, we present and discuss the findings from the study. We conclude with practical implications for the management of diverse innovation teams.

THOUGHT DIVERSITY AND INNOVATION OUTCOMES

We define thought diversity both as (i) variety in team members' educational and functional perspectives and as (ii) predominance, among members, of two approaches to problem solving, which past research has identified as closely tied to innovation (Jabri, 1991; Kirton, 1976; Koestler, 1989). Diversity in perspectives exists on a team when members represent a variety of learned perspectives that is, learned ways of perceiving and interpreting the world that come from being trained in a particular field or from working in a given functional area. Lawrence and Lorsch (1967) argued that organizations must integrate the differences in ways of thinking across functions in order to be high performing. For example, they noted that the differences in time orientation in sales versus research could cause misunderstandings and conflict that might impede performance. Representation of various educational (e.g., engineering, science, business) and functional (e.g., marketing, engineering, basic research, production) backgrounds among its membership provides a team with more knowledge and expertise from which to draw. Furthermore, team members from various backgrounds also connect the team to more sources of ideas because of the members collectively having broader networks than teams composed of those with more homogenous backgrounds. Finally, representation from a variety of organizational functions also helps teams comprehend a problem's complexity as well as address the potential impact of a proposed innovation throughout the organization.

Heuristics – or, problem solving approaches – provide a team with alternate, independent ways to resolve a problem or to innovate. Two problem solving approaches in particular are of interest in the study of innovation: the sequential approach and the cross-disciplinary approach (Jabri, 1991; Kirton, 1976; Koestler, 1989). The sequential approach involves following an existing set of logical, sequential routines to solve a problem (Jabri, 1991). Using a cross-disciplinary approach means considering many factors at once, linking previously unconnected ideas (Jabri, 1991) and superimposing different interpretation frames on a given situation (Koestler, 1989). Team members are likely to vary in their problem solving approaches. In addition, the approaches are independent from each other, i.e., being highly sequential does not imply that one will not be cross-disciplinary. Any given team member could favor sequential thinking, cross-disciplinary thinking, both, or neither. That is, while most individuals prefer using one approach over another, some versatile individuals utilize both approaches in their team interactions. Furthermore, the two problem solving approaches in our study are closely tied to personality attributes and can therefore readily be measured with different personality tests. Some firms, for example, require employees to take the Kirton Adaptor Innovator (KAI) Inventory. [2] Most personality traits are partly genetically determined and partly learned. Hence, individuals can learn to approach problems sequentially or cross-disciplinary thinking, using

[2] While the KAI Inventory helps differentiate between sequential thinkers and cross-disciplinary thinkers, one caveat is that it assumes individuals use either the sequential or the cross-disciplinary approach in all situations, even though other research has shown that individuals can be flexible in their problem solving styles, and use them interchangeably.

defined sequences of steps (e.g., six sigma, morphologic analysis) or using cross-disciplinary thinking tools (e.g., analogizing, abstracting).

Neither the sequential nor the cross-disciplinary heuristic is universally preferable (Payne, Lane, & Jabri, 1990). However, the sequential problem solving approach, with its emphasis on logical, sequential analysis within known parameters, is likely, to the extent that innovation emerges, to lead to incremental (rather than radical) innovations. In contrast, the cross-disciplinary problem solving approach is more likely to lead to radical innovation, because it underlies a preference for combining varied knowledge in novel ways and moving beyond existing boundaries and rules. If a given approach to problem solving is especially prevalent on a team, it may explain why that team is more likely, for example, to produce incremental versus radical innovation (or vice versa).That is, a team's aggregate preferences for the sequential and cross-disciplinary approaches may help explain why some teams deliver radical innovations while others supply incremental innovations. As these problem solving styles are measured independently from each other, we do not assume that the prevalence of sequential thinking means the absence, on that team, of cross-disciplinary thinking.

THOUGHT DIVERSITY & TEAM DYNAMICS

While a team's thought diversity may directly affect innovation, it may also affect team dynamics that are critical to innovation, namely collaborative learning (e.g., learning together and from each other), psychological safety (e.g., a belief that expressing opposing views will not lead to rejection or other negative consequences), and shared mindset (i.e., a shared way of seeing and understanding things.) For thought diversity to deliver on its potential for higher innovation, members of diverse teams must collaboratively learn from each other, must feel psychologically safe, and must resist developing a shared mindset. Teams whose thinking becomes too alike risk losing the value of the diversity of thought among team members, so the development of a shared mindset, which often emerges in teams over time, is a team dynamic that should be mitigated if innovation is to take place. While previous work has shown how problem solving approaches affect innovation, less is known about how sequential and cross-disciplinary thinking affect the team dynamics (i.e., collaborative learning, psychological safety, and shared mindset) that facilitate or hinder innovation. We contend that teams that are homogeneous in their problem solving approaches search for innovations along similar paths. However, because of the inherent differences between the two problem solving styles, we argue that homogeneity in sequential thinking (i.e., when all members share a strong preference for sequential thinking) and homogeneity in cross-disciplinary thinking (i.e., when all members share a strong preference for cross-disciplinary thinking) lead to different group dynamics.

Collaborative Learning

Innovations often require the collaboration of competing, but interdependent organizational team members. Teams composed of task-related experts perform much better when members collaborate and integrate their expertise rather than when members accept the expertise of individual team members without bringing their own knowledge to bear such that team members rely on each other (Woolley, Gerbasi, Chabris, Kosslyn, & Hackman, 2008). Consequently, for a diverse team to innovate, members need to be committed to mutual, collaborative learning. Under these circumstances, teams that organize their interactions to learn from each other are more likely to realize their innovation potential (Shrum, Chompalov, & Genuth, 2001). Janz and Prasarnphanich (2003) note that interactions in which team members mutually educate and encourage each other to accomplish tasks and to promote each others'

successes are an important prerequisite of team learning. That is, to be successful, team members must not only focus on their own learning, but also be able to ensure that others are learning from them. Therefore, collaborative learning, which we define as careful, purposeful, and attentive interactions around learning (Ryle, 1949), is an important process for achieving innovation on a team. Collaborative learning fosters innovation because it improves the chances that divergent views expressed by members with different knowledge and perspective are understood and taken into consideration by others on the team.

Because members of educationally and functionally homogeneous teams "speak the same language," they may find it easier to listen to and understand others. In contrast, when members of a team represent a variety of perspectives, they may expect others to have different knowledge and perspectives than the ones they carry. However, unless otherwise encouraged, members on educationally or functionally diverse teams may divide the team's tasks into subtasks. The team may then delegate the subtasks to functional or discipline experts rather than spend the time and energy learning from others and articulating their knowledge for others to learn. In this case, in the way suggested by Katzenbach and Smith (1993), the team doesn't really behave as a team but as a working group, thereby sub-optimizing innovation potential.

When all team members lean toward the logical, sequential approach to innovation, they are not compelled to understand or question how they and others think; hence the collaborative learning on such a team will be low. Cross-disciplinary thinkers, in contrast, enjoy searching for novel approaches beyond what is required at the time, but the novel approaches that might be introduced by cross-disciplinary thinkers are likely not to be communicated or understood among team members unless there are careful, purposeful, and attentive interactions among team members. Hence, we think that as the number of cross-disciplinary thinkers increases on teams, members are increasingly likely to engage in collaborative learning to help them understand each other's approaches.

Psychological Safety

Psychological safety fosters innovation because when individuals feel that they will suffer negative consequences (e.g., criticism, social rejection) for disagreeing with other team members, they are less likely to contribute unique information or offer divergent perspectives (Edmondson, 2002) that are essential if teams are to learn and innovate.

In teams dominated by one educational discipline or functional area (that is, teams with limited diversity in perspectives), the dominant educational discipline or functional area may also be perceived by those with divergent perspectives to be more powerful, that is as having more influence in the organization. Power asymmetries reduce feelings of psychological safety (Edmondson, 2002). Hence, individuals from a minority educational or functional perspective may think twice before expressing an opinion that is contrary to that of the majority, or before contributing information contradictory to that proposed by the majority. As they silence themselves, team members also develop negative emotions toward the team (Perlow, 2003). In contrast, in teams with a wide diversity in perspectives, the absence of a majority may lead to more psychological safety. That is, we predict that teams with more perspective diversity are more conducive to individual risk-taking that contributes novel and divergent ideas to the team (compared to teams with homogeneity in members' perspectives.)

Because cross-disciplinary thinkers enjoy the challenge of integrating a variety of perspectives, individuals on teams composed of cross-disciplinary thinkers may feel invited to contribute unique information and see little risk in offering new ideas. Therefore, we expect to see more psychological safety in teams composed of cross-disciplinary thinkers than in teams

where members mostly use the sequential approach to problem solving. In fact, when the majority of members favor sequential thinking any deviation from the well-trodden path for resolving problems is likely to be frowned upon. Because of those circumstances, we predict that psychological safety will be low on teams that lean toward sequential thinking and, therefore, unique viewpoints on how to proceed (i.e., shared mindset) are unlikely to emerge.

A Shared Mindset

One important explanation for poor decision-making and lack of creativity in groups is the reliance of group members on a shared mindset. While teams with a shared mindset may find it easier to engage organizational members into action, they are also likely to distort information and data to fit the mindset that the team developed. Furthermore, innovation is less likely to occur on teams with a shared mindset, because individuals often construe a team's shared mindset as correctness (Stasser & Birchmeier, 2003). That is, when the team has developed a shared mindset (e.g., about the team's assumptions, methods, and processes for example), members may refrain from challenging it and become less likely to share unique information, perspectives, or interpretations that deviate from the consensual way of thinking (Stasser & Titus, 1987). In contrast, teams without a shared mindset invite alternate interpretations of information and data in the innovation process. And, the provision of alternate interpretations provides a basis for team learning.

Information that is held in common by all members holds undue influence on the team's decision-making process. Therefore, a shared mindset will often arise when a majority of team members hold similar views or have access to similar information. In contrast, when team diversity increases, a shared mindset becomes more difficult to achieve. In addition, because cross-disciplinary thinkers search for new ideas and novel approaches beyond what is required at the time, we argue that a shared mindset is less likely to occur on teams where cross-disciplinary thinking is dominant. In contrast, we expect that a shared mindset will more readily emerge on teams where members use the sequential approach to problem solving, because of the underlying agreement about using proven methods to solve problems. That is, fewer divergent ideas are likely to arise in teams whose thinking has converged in a shared mindset and where team members begin to think more alike.

Sample & Methods

Our sample consists of 28 innovation teams from 14 companies representing a variety of industries. Member companies of a subcommittee of the Industrial Research Institute (IRI), the primary professional association of industrial R&D executives, were invited to participate in a study on thought diversity and innovation by volunteering product, service, or process innovation teams from their organization to participate in a 30-minute online survey. A team was eligible to participate in our study if it included R&D members and was cross-functional; if it had at least seven members; if its members had spent a minimum of three months together; and if it was still operating or had disbanded no more than sixty days prior to the study.

Team members' response rate for the on-line survey was 92% with a total of 283 usable surveys. Half of the teams achieved a 100% response rate. On the remaining teams the response rate averaged 86% with a range from 75% to 96%. Our research design included team innovation evaluations from both team members and from one or more stakeholders for each team. In other words, stakeholders for each team completed a shorter (15-minutes) version of the online survey that provided an outsider's perspective on the team's performance. The response rate among

stakeholders was also high (89%) with a total of 33 stakeholders responding. The surveys included both established measures and measures stemming from a series of semi-structured interviews conducted in an earlier phase of the study.

The mean team size was 11 members, with a range from 4 to 28. The number of different functions present on teams ranged from 1 to 9, with an average of 4. The number of different educational backgrounds present on any given team ranged from 1 to 5, with an average of 3. Our sample represents the following industries: communications equipment, computers and peripherals, food products, household products, machinery, materials and chemicals, textiles, petrochemicals, and specialty retail.

In this study, we conceived of innovation in two different and well established ways. First, we were interested in the extent to which teams engage in innovative behaviors, such as searching out new technologies, processes, techniques, and/or product ideas, or mobilizing support from outside the team to gain approval for the team's ideas. We were also interested in the radicalness of teams' work, that is, how new and different the innovation was relative to what already existed in the company and in the market. Consistent with these two ways of thinking about innovation, we used two measures of innovation and, for each, relied on two sources of information: team members and team stakeholders (i.e., individuals who were not on the team but cared about, and had a stake in, the team outcomes).

To measure team members' perceptions of their team's innovative behaviors, we drew on the scale developed by Ramamoorthy and colleagues (2005). The extent to which teams engaged in innovative behaviors was measured with members' level of agreement with five statements such as "In order to move ahead, the team takes the risk of advancing further than its current knowledge permits." Drawing on existing measures (Leifer et al., 2000; O'Connor & DeMartino, 2006; Wilson, Ramamurthy, & Nystrom, 1999), we assessed team members' perception of radicalness by asking for their agreement with five statements pertaining to the nature of the innovation, such as: "From a technical perspective, the innovation would be best described as new and different from what has existed previously in the company." Responses were given on a seven-point scale from "strongly disagree" (1) to "strongly agree" (7). Principal components factor analysis of the ten items revealed that the innovative behaviors and radicalness items loaded on two distinct factors. Thus each set of items was respectively averaged to create a scale of team-reported innovative behaviors ($\alpha = .84$), and a scale of team-reported radicalness ($\alpha = .80$). We aggregated individual team member data to develop team-level perceptual measures of innovation (Chan, 1998; Molleman, 2005).

We measured stakeholders' perceptions of team innovative behaviors with four of the five items used for team members and their perceptions of team radicalness with two of the five items used for team members. Principal components factor analysis of the six items revealed that the stakeholder-rated innovative behaviors and radicalness items loaded on two distinct factors. Thus each set of items was respectively averaged to create a scale of stakeholder-reported innovative behaviors ($\alpha = .81$), and a scale of stakeholder-reported radicalness ($\alpha = .62$).

To measure a team's diversity of perspectives, we computed an index of dissimilarity (Blau, 1977) using team members' educational backgrounds (i.e., subject areas for highest degree attained). We computed another index of dissimilarity (Blau, 1977) using team members' functional backgrounds, defined in terms of their primary job responsibility as the source of diversity. Blau indices range from 0, which indicates that the team is homogeneous on the measured dimension to 1, which indicates maximum diversity (e.g., each member represents a different educational or a different functional background.)

To measure team heuristics, we drew on existing measures (Jabri, 1991; Kirton, 1976) to assess individual proclivities for the sequential problem solving approach and the cross-disciplined problem solving approach. We assessed the preference for the sequential approach by asking for respondents' agreement with five statements, such as: "I prefer being methodical in the way I tackle problems." The preference for the cross-disciplined approach was evaluated with responses to three statements, such as: "I enjoy the challenge of making connections between apparently unrelated ideas." Responses were given on a seven-point scale from "strongly disagree" (1) to "strongly agree" (7). Principal components factor analysis of the eight items revealed that the sequential and cross-disciplined items loaded on two distinct factors. Thus each set of items was respectively averaged, at the individual level, to create a scale of preference for sequential approach ($\alpha = .73$), and a scale of preference for cross-disciplined approach ($\alpha = .74$). We averaged team member data to develop a measure of teams' mean proclivity for the sequential and a measure of teams' mean proclivity for the cross-disciplined approach (Chan, 1998; Molleman, 2005).

Our survey included established, reliable, multi-item measures for the three team dynamics of interest. Collaborative learning was measured with team members' agreement to six statements such as: "This team takes the time to have members learn each other's perspectives." The items, which loaded onto one factor ($\alpha = .89$), were averaged into a scale. We measured psychological safety with team members' agreement to three statements such as: "People on this team sometimes reject others for being different." We averaged the three items, which loaded onto one factor ($\alpha = .70$) into one scale. Shared mindset was measured with team members' agreement to three statements such as: "On this team, we all see things pretty much the same way." The items loaded onto one factor ($\alpha = .67$) and were averaged to create this scale. Responses were given on a seven-point scale from "strongly disagree" (1) to "strongly agree" (7). As was the case with our other measures, individual team members' responses were aggregated to produce the team-level measures.

Because of the greater likelihood that longer-standing teams perform better (Hackman, 2002) and are more innovative (West & Anderson, 1996) than teams with shorter tenure, in our analyses we controlled for the amount of time team members reported having been part of their team. While team size may influence team dynamics, separate analyses showed that the pattern of our results are independent of the effect of team size.

Results

Table 1 provides the means, standard deviations, and bi-variate correlations for the variables in our study. Almost forty percent of the teams had worked together for 2 years or more. Educational diversity was not correlated with functional diversity among the teams in our sample. In some teams, there was high educational variety, but all members were in the same function. Conversely, some teams had high functional variety, but individuals on the team had similar educational backgrounds. Teams with a high aggregate preference for sequential thinking did not necessarily reject cross-disciplinary thinking and vice versa. That is, if a team disliked or was indifferent to cross-disciplinary thinking, it does not necessarily follow that the team had a strong preference for sequential thinking (or vice-versa).

{Insert Table 1 about here}

TEAM DYNAMICS AND INNOVATION

Among the teams in this study, we found – as expected – that collaborative learning fosters innovation. As shown in Table 2, on teams that reported more collaborative learning, team members also reported engaging in more innovative behaviors and producing more radical innovations. Psychological safety was also beneficial for innovation: the more psychologically safe team members felt, the more they reported engaging in innovative behaviors. Finally, a greater shared mindset was detrimental to innovation: in teams with a strong shared mindset, members were less likely to rate the team's innovation as radical.

{Insert Table 2 about here}

THOUGHT DIVERSITY AND TEAM DYNAMICS

As reported in Table 3, we found that more functionally diverse teams reported less collaborative learning and that educational diversity was not associated with collaborative learning at a statistically significant level. One possible explanation for the negative relationship between functional diversity and collaborative learning is that members exploit their diversity by relying on the special expertise of functional representatives, rather than leveraging it by seeking to integrate their different perspectives. This seems to fit with our other finding that members of functionally diverse teams did not perceive themselves to be innovative, even if stakeholders perceive them to display more innovative behaviors and produce more radical innovations than teams with less functional diversity.

{Insert Table 3 about here}

In Table 3, we note that more functionally diverse teams reported less psychological safety and less of a shared mindset than teams with members who were similar in their functional background. This suggests that members of functionally diverse teams seem more anxious about voicing divergent opinions and may chose to silence unique and contradictory viewpoints rather than risk being perceived as 'rocking the boat.' However, the lesser shared mindset on functionally diversity teams suggests that having a wide diversity of perspectives blocks the development of a shared way of interpreting information. The lesser shared mindset on functionally diverse teams may explain why the stakeholders of these teams perceived them to be more innovative in their behaviors and more radical in their work than team members perceive themselves to be: functional diversity compels team members to keep seeking new ideas and new perspectives rather than concurring. However, it appears from our analysis, that even though functionally diverse teams were able to avoid creating a shared mindset, members of such teams still felt anxious about voicing divergent opinions or sharing information conflicting with that already held by the team.

As shown in Table 3, we also find that collaborative learning was lower on teams with a high aggregate preference for sequential thinking, confirming our expectation that when team members (on average) exhibit a strong preference for taking a logical, sequential approach to innovation, they do not feel compelled to understand or question how they and others think. Since teams that learn collaboratively also perceive themselves to be more innovative, the shortage of collaborative learning in sequentially thinking teams may explain why members of these teams were less likely to report innovative behaviors than members of teams that were less reliant on sequential thinking.

Teams in our study with a high proclivity towards cross-disciplinary thinking engaged in more collaborative learning, as we show in Table 3. Cross-disciplinary thinkers enjoy searching

for novel approaches beyond what is required at the time; such novel approaches cannot be communicated or understood without careful, purposeful, attentive interactions among team members. Because members in teams made up primarily of cross-disciplinary thinkers may find it difficult, at the outset, to understand each other, they apparently engage in collaborative learning to help themselves understand each other's approaches. In turn, because collaborative learning fosters innovation, the collaborative learning that occurs in cross-disciplinary thinking teams may explain why members of such teams are more likely to report producing radical innovations than members of teams with a less strong emphasis on cross-disciplinary thinking. Neither educational diversity, nor sequential thinking, nor even cross-disciplinary thinking was correlated with psychological safety or a shared mindset in our study.

THOUGHT DIVERSITY AND INNOVATION OUTCOMES

The findings reported in Table 4 suggest that the benefits of perspective diversity lie in the eyes of the beholder. Stakeholders (but not members) of functionally diverse teams were more likely to report that those teams exhibited innovative behaviors and produced radical innovation. Further, the predominant problem solving approach of a team shaped team members' (but not stakeholders') perception of a team's innovative behaviors and radicalness. As reported in Table 4, as teams' reliance on sequential thinking increased, members reported less innovative behaviors (e.g., they were less likely to search out new technologies, processes, techniques, and/or product ideas). On teams that relied heavily on cross-disciplinary thinking, members were more likely to report accomplishing radical innovation. So, people outside innovation teams (i.e., stakeholders) described functionally diverse teams as more innovative, while members of such teams did not perceive themselves to be more or less innovative than members of functionally homogenous teams.

While neither members nor stakeholders of educationally diverse teams reported more innovation, other analyses (not reported here) showed that the advantage of educational diversity is that it diversifies the approaches to problem solving among team members. In other words, educational diversity did not offer any benefits above and beyond the benefit of reducing a team's reliance on the sequential problem solving approach (which, as we will see, inhibits innovative behaviors).

{Insert Table 4 about here}

Limitations, Discussion and Implications

Our study has some limitations. First, because the teams in our study span industries, companies, and are at different stages of the innovation process, we used a subjective measure of innovation that would enable us to compare teams in our diverse sampling frame. While subjective evaluations are sometimes prone to distortions, team members' subjective evaluations of the team's performance exert real influences on members' attitudes toward, and behavior on the team. Similarly, stakeholders' subjective evaluations shape decisions that affect a team's survival and resources. Another limitation, common to study like ours, is that it relies on data collected at one point in time. Hence, causality cannot be empirically established. Also, because of the small size of our sample, we run the risk that some real relationships between the variables under study are not statistically detected. Finally, while the companies sampled for this study represent a variety of industries, they all had expressed a strong interest in the topic of thought diversity and innovation. Hence, they are not completely random. Gaining access to individuals

on innovation teams is extremely difficult as companies are reluctant to open their doors for outsiders to survey personnel involved in the development of breakthrough projects on which organizational survival and prosperity may hinge. The chances of gaining such access to a large number of teams, and of randomly selecting teams from all teams within each company are very slim. Under such circumstances, our research team developed close ties over several years with a research subcommittee of the Industrial Research Institute (IRI). IRI member companies are representative of the variety of companies engaged in scientific or engineering innovation in the U.S., and the companies represented in our sample agree to participate, because they were particularly interested in the topic of leveraging thought diversity for innovation.

Despite these limitations, the findings from this study are noteworthy because they shed some light on how thought diversity (defined by the variety of perspectives and the dominant problem solving approach among team members) affects team dynamics and innovation outcomes. The results also provide some guidance on composing (or re-composing) teams to encourage innovative behaviors. Not only must organizations ensure that the members of innovation teams represent a wide variety of functions; they must also create the conditions for innovation in their diverse teams such that (i) members help each other learn from one another (i.e., encourage collaborative learning), (ii) members with unique perspective feel comfortable voicing their own opinion (i.e., cultivate psychological safety), and (iii) team members maintain divergence in their ways of thinking (i.e., they are able to avoid developing a shared mindset.) Organizations that create environments where members on functionally diverse teams are willing to learn collaboratively, feel safe to voice divergent opinions, and avoid a shared mindset may gain considerable competitive advantage in developing breakthrough innovation.

In the eyes of stakeholders, functionally diverse teams exhibit more innovative behaviors and produce more radical innovations than functionally homogenous teams. While the members of highly diversified cross-functional teams report less collaborative learning and less psychological safety, members on these teams are also less likely to maintain divergence rather than develop a shared mindset. It is likely that this divergence helps the team achieve more innovation (as reported by stakeholders) while the poor interpersonal dynamics (lack of collaborative learning and lack of psychological safety) tend to dampen team members' perceptions of their work outcomes (i.e., innovative behaviors and radicalness). Among the teams in our study, when members reported low collaborative learning, low psychological safety, and a lesser shared mindset, they also reported lower levels of innovative behaviors than stakeholders perceived them to be demonstrating. Our results may reflect a self fulfilling process of sorts by stakeholders. If stakeholders perceive that, in order to innovate, the main obstacle is organizational silos, they might assume that more functionally diverse teams are more innovative just because they are structured to overcome the silos.

The more teams engage in collaborative learning the more likely they are to realize their innovation potential (Janz et al., 2003; Shrum et al., 2001). Because members of functionally diverse teams tend not to learn collaboratively, they are missing out on an opportunity to provide more innovative work. Hence, the lack of collaborative learning on functionally diverse teams may explain why team members perceive their work to be less innovative than stakeholders do. To capitalize on the value contributed by functional diversity, attention must be given to ways to enhance collaboration so that team members learn from each other and mutually educate and encourage each other to accomplish tasks and to promote each other's success.

The degree of educational variety among team members has no detectable influence (above and beyond the influence of functional and thought diversity) on teams' dynamics,

innovative behaviors, or radicalness. Even so, the results in our study suggest that increasing educational diversity on a team also increases the degree of cross-disciplinary thinking reported by team members. Hence, increasing the educational diversity of team members may provide the team with problem solving approaches that foster innovation.

The relationships among dominant problem solving approaches in innovation teams, collaborative learning, and innovation outcomes (innovativeness and radicalness) form a consistent pattern in our data. Teams composed primarily of cross-disciplinary thinkers report more collaborative learning and perceive their work to be more radical. In contrast, teams composed primarily of sequential thinkers report less collaborative learning and fewer innovative behaviors. Our findings are in line with anecdotal evidence about the risk that highly structured programs like Six Sigma may be detrimental to radical, breakthrough innovation (Hindo & Grow, 2007; Richardson, 2007). An implication of our findings is that for a team tasked with radical, breakthrough innovation to succeed, members must approach the innovation challenge with cross-disciplinary thinking, because such thinking tends to promote collaborative learning, which, in turn, fosters innovation.

In this regard, diversifying teams' problem solving approach may promote innovative behaviors among team members. This can be done by introducing individuals with less of a proclivity toward sequential thinking or by building team norms that encourage members to deviate from sequential thinking. Personality assessments such as the Kirton Adaptor Innovator (KAI) Inventory may help identify individuals who are less sequential in their thinking. Increasing the educational diversity among team members can also help break a team's excessive reliance on sequential thinking. Role-playing techniques (e.g., devil's advocate or structured debates) may provide other avenues to encourage teams to move away from sequential thinking. However, some research has shown that authentic disagreement is more valuable than role-playing techniques in helping teams avoid developing a shared mindset (Nemeth, Brown, & Rogers, 2001).

Our findings also suggest that teams that want to retain the ability to develop radical innovation should maintain and encourage cross-disciplinary thinking. One way to do this is by decreasing the proportion of sequential thinkers and increasing the proportion of cross-disciplinary thinkers on the team. Another way to promote cross-disciplinary thinking on a team is to purposely limit the use of proven methods for problem solving and de-emphasize preciseness and exactness in team results and reports. For example, to reduce the likelihood that development teams commit to a single, well established process too quickly, Thompke (2001) recommends rapid parallel experimentation, that is, testing different concepts and ideas simultaneously and early rather than adhering to entrenched processes that commit the team to a particular way of thinking about an innovation challenge. Rapid parallel experimentation increases the chances that technologies can be combined and opens the door to different ways of addressing innovation challenges.

Interestingly, our results suggest that stakeholders' evaluations of innovation teams are independent of the dominant problem solving approach among team members. That is, any effect of a team problem solving approach on team members' perceptions of their work outcomes does not seem to affect stakeholders' evaluations of the team's outputs. This may be because team members' dominant problem approach is not visible to outsiders (i.e., stakeholders) or because stakeholders may be more sensitive to organizational conflict and or status and power issues stemming from the functional composition of the team rather than to the technical and learning/creativity issues that the team understands better. Conversely, team members'

evaluations of their team's innovativeness (both in terms of behaviors and radicalness) are independent of its' functional composition. Here again, this may be because team members are more sensitive to the team dynamics than to the functional composition of the team per se (DiTomaso, Cordero, & Farris, 1995).

Managers have become increasingly aware of the need to leverage diversity as a means to increase innovation. At the same time, the multiple and often contradictory team dynamics that arise in diverse teams present scientific organizations with major challenges. In light of these challenges, the goal of this study was to develop an understanding of how an innovation team's thought diversity affects its team dynamics and innovation outcomes. While research to-date has mapped out the effects of demographic diversity (e.g., gender, race/ethnicity, age, tenure) and the mechanisms by which it works within groups, our study has contributed new insights about the inter-related nature of diversity of thought in teams (e.g., diversity in perspectives and in approaches to problem solving), team dynamics and innovation.

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Table 1. Means, Standard Deviations, and Bivariate Correlations

	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Long Team Tenure	0.39	0.50											
(2) Educational Diversity	0.47	0.18	-.400*										
(3) Functional Diversity	0.62	0.16	-.392*	.311									
(4) Mean Sequential Thinking	5.07	0.46	.113	-.513**	-.235								
(5) Mean Cross-disciplinary Thinking	5.87	0.40	.188	.087	.033	.077							
(6) Collaborative Learning	5.17	0.44	.325	.150	-.280	-.288	.368						
(7) Psychological Safety	5.62	0.52	.095	.209	-.280	-.282	-.024	.673**					
(8) Shared Interpretive Scheme	5.08	0.47	.537**	-.099	-.547**	.154	.193	.564**	.496**				
(9) Team-reported Innovative Behaviors	5.52	0.51	.381*	.235	-.220	-.429*	.161	.750**	.673**	.397*			
(10) Team-reported Radicalness	5.58	0.63	.330	.157	.010	-.291	.387*	.424*	.286	.072	.683**		
(11) Stakeholder-reported Innovative	5.47	1.00	.253	-.063	.314	-.210	.130	.062	-.103	-.109	.257	.567**	
(10) Stakeholder-reported Radicalness	5.51	1.29	.314	-.048	.237	-.090	.163	.186	-.059	.006	.293	.597**	.726**

*. Correlation is significant at the 0.05 level

**. Correlation is significant at the 0.01 level

Table 2. Regressing Team Innovation on Team Dynamics

	Team-reported Innovative Behaviors	Team-reported Radicalness	Stakeholder-reported Innovative Behaviors	Stakeholder-reported Radicalness
Constant	1.48 †	4.27 **	7.90 **	6.53 †
Team Tenure	0.34 *	0.57 *	0.83 †	0.99
Collaborative Learning	0.59 **	0.61 †	0.50	1.07
Psychological Safety	0.43 *	0.26	-0.16	-0.45
Shared Mindset	-0.31	-0.69 *	-0.88	-0.86
Adjusted R-square	0.64 ***	0.24 *	0.03	0.06

† $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

Table 3. Regressing Team Dynamics on Thought Diversity (Perspectives & Heuristics)

	Collaborative Learning	Psychological Safety	Shared Mindset
Constant	4.95 **	7.75 ***	4.02 **
Team Tenure	0.20	0.07	0.42 *
Educational Variety	0.32	0.66	0.74
Functional Variety	-0.88 †	-1.22 †	-1.22 *
Mean Sequential Thinking	-0.34 †	-0.30	0.14
Mean Cross-disciplinary Thinking	0.38 †	-0.03	0.10
Adjusted R-square	0.28 *	0.06	0.37 **

† $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

Table 4. Regressing Team Innovation on Thought Diversity (Perspectives & Heuristics)

	Team-reported Innovative Behaviors	Team-reported Radicalness	Stakeholder-reported Innovative Behaviors	Stakeholder-reported Radicalness
Constant	7.02 ***	4.13 †	5.50	2.80
Team Tenure	0.43 *	0.46 †	0.74 †	1.18 †
Educational Variety	0.75	0.40	-1.10	-0.26
Functional Variety	-0.73	0.14	2.80 *	3.20 †
Mean Sequential Thinking	-0.46 *	-0.40	-0.55	-0.20
Mean Cross-disciplinary Thinking	0.13	0.52 †	0.20	0.23
Adjusted R-square	0.34 *	0.20 †	0.16	0.09

† $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$