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A Dimensional Model for Describing and Differentiating Project Teams

Abstracts

Most of the existing studies focus on using taxonomic structures to define different project team types; however, little consensus has been reached on the classification. This paper holds that greater consensus could be achieved by using a dimensional scaling approach to describe project teams. Based on the last 35 years of project team research, a conceptual model is presented for describing and differentiating project teams according to seven dimensions: skill differentiation, interdependence, authority differentiation, team size, team longevity, virtuality, and sharedness. In addition, we illustrate the interrelationships among the dimensions. By using this model, we further explain how the 18 types of project teams discussed in the literature could be more effectively presented. Implications of the model as well as its limitations and possible future research directions are also explored.

Keywords: Dimensional Model, Project Teams, Interdependence, Differentiation

1. Introduction

In the increasingly fast-changing 21st century, project teams represent a primary vehicle for conducting work in contemporary organizations (Furst et al., 2004; Gardner et al., 2012; Haas, 2006) because they serve as flexible structures that promote expertise sharing and knowledge building (Chiocchio and Essiembre, 2009). Well-known examples of successful project teams include the team that developed Macintosh and the teams that undertook the 2010 Shanghai World Expo construction project. Research on project teams has in parallel increased and grown in diversified directions (Hollenbeck et al., 2012). Although the diversity of research provides a rich ground for theory building, it also creates certain challenges. Perhaps one of the biggest challenges is how to integrate and aggregate findings across studies when each study defines project teams differently.

Given this context, it would be advantageous to develop a system that helps researchers describe more precisely what kind of project team is the target of study. Traditionally, taxonomic structures were employed to classify project teams. This classification method has the great limitation of being dichotomous. If a project team is not one type, then it must be another type. This approach produces difficulties for researchers trying to define project teams in their studies. Therefore, little consensus has been reached through using taxonomic structures.

This paper aims to develop a dimensional scaling approach for describing and differentiating project teams. Dimensional scaling allows us to quantify teams along continuous dimensions and avoid either/or categorizations (Nunnally et al., 1967). Specifically, in this paper, we first review the project team literature to show the seven dimensions used in our conceptual model. Second, we illustrate the relationships between dimensions. Third, we demonstrate how the 18 project team types used in previous studies can fit into our model. Finally, we discuss our model's applications in knowledge accumulation, theory building, and managerial practices.

2. Literature Review

2.1 Literature search and inclusion rule

A search of the existing literature was conducted using the search terms "project teams" more broadly and in the "construction industry" more specifically. Peer-reviewed journal publications between 1981 and 2016 were identified by searching the five most prominent management journals (the *Academy of Management Journal*, *Academy of Management Review*, *Administrative Science Quarterly*, *Management Science*, and *Organization Science*), and the four prominent journals in the construction industry (*International Journal of Project Management*, *Journal of Construction Engineering and Management*, *Journal of Management in Engineering*, and *Project Management Journal)*.

The search generated 78 journal articles that met one or more of the following search criteria:

(1) The articles were related to team dimensions;

(2) The articles were related to project team literature.

To ensure we included all important and relevant journal articles in the study, we expanded the search by using the reference section of the above articles to further identify a total of 35 papers published in, to name a few, the *British Journal of Management*, *Harvard Business Review, Journal of Applied Psychology*, *Journal of Management*, *Journal of Organizational Behavior*, *MIS Quarterly, Small Group Research,* and *The Academy of Management Perspectives*.

A total of 113 publications were analyzed to determine the dimensions of our model, the interrelationships among the dimensions, and how to explain different project teams using our model.

2.2 Taxonomic approach

Over the past 35 years, the literature has presented a variety of taxonomic structures for describing and differentiating project teams. Here we first review research that describes project teams and some of their instrumental performance traits more broadly. Then we review taxonomic research that seeks to further differentiate different types of project teams.

For description, Sundstrom et al. (1990) defined teams into four types: advice/involvement teams, production/service teams, action/negotiation teams, and project/development teams. They used specialization, external integration, and work cycles to compare the four types of teams: specialization and external integration of advice/involvement teams are minimal, and work cycles can be brief or long, while specialization and external integration of action/negotiation teams are high and work cycles are usually brief; the contexts of production/service teams demand low specialization and high external integration and work cycles are typically repeated or continuous; project/development teams were described as groups with high specialization and low external integration, and one work cycle is often the team life span.

Cohen and Bailey's (1997) reviewed about four types of teams (work, parallel, project, and management teams) and identified team composition (diversity) and group processes (internal and external communication) as well as autonomy and group psychosocial traits (shared group understanding) as critical team-level factors affecting team performances. They argued that external communication was a characteristic that distinguishes project teams from work, parallel, and management teams. The authors also pointed out that while autonomy was a positive predictor of work team performance, under some circumstances, it was "neither a desired or beneficial characteristic of project teams" (p. 261). Another of their key conclusions was that functional diversity in some cases negatively affected project team performance. In their sample of project team research, internal communication was found to be positively associated with team performance. What's more, they suggested considering the impacts of shared team understanding on project team performance.

Similarly, Brown and Eisenhardt (1995) focused on team composition (functional diversity, gatekeeper, team tenure), and group processes (internal and external team communication) as they related to project teams in product development settings. Effective product development teams were characterized by cross-functional team composition, the presence of "gatekeepers", moderate team tenure, high internal and high external communication. Edmondson and Nembhard (2009) also reviewed project teams in new product development (NPD). In addition to cross-functionality, internal and external interdependence as attributes of NPD teams, Edmondson and Nembhard (2009) identified virtuality as having become an important attribute of project teams due to advances in communication technology.

For differentiation, Katz (1982) broke down R&D project teams into three types: research, development, and technical service project teams. While the above review highlighted internal and external communication as distinct attributes of project teams, Katz found that levels of internal and external team communication were contingent on project characteristics. For example, research project teams reported high levels of external communication, while development and technical service project teams maintained high levels of internal communication (ibid.).

According to the forms of external activity that a team engaged in, Ancona and Caldwell (1992a) categorized project teams for product development as ambassadorial, technical-scouting, isolationist, or comprehensive teams. Ambassadorial teams carry out external communication with managers in the organizational hierarchy to seek protection, support, and resources. Comprehensive teams not only focus on ambassadorial activities but also coordinate and negotiate with outsiders. However, this type of team has less internal cohesiveness than pure ambassadorial teams. Technical-scouting teams coordinate and negotiate with outsiders as well as gather information about the outside market, technology, and competition. But this type of team pays the price for the large amounts of outside information, which complicates internal interaction and can induce internal conflicts. In contrast, isolationist teams seldom communicate with outsiders but maintain high levels of internal cohesiveness. In sum, Ancona and Caldwell (1992a) implied a trade-off between external activity and internal cohesiveness in project teams.

Based on the degree of technological uncertainty, Shenhar (1998) differentiated project teams into low-tech, medium-tech, high-tech, superhigh-tech project teams. Shenhar (1998) indicated that specialization was related to team communication. For example, low-tech project teams (e.g., construction teams) rely on mature technologies and primarily employ semiskilled workers to rebuild a project that was previously designed. These teams usually adopt formal communication mechanisms between managers and team members. In addition to using mature technologies, medium-tech project teams (e.g., automobile modification) also involve some new technology to implement incremental innovation. Medium-tech project teams integrate a wide range of special expertise in technology development. As a result, formal communication is more intense than in low-tech teams, and informal communication is also conducted to solve occasional problems. High-tech project teams (e.g., new product development teams) rest significantly on new technologies. To develop products that are entirely new to the market, high-tech teams assemble several highly qualified professionals from different departments. These professionals frequently communicate with team members and outsiders (e.g., their home departments, customers) to review their major decisions. Superhigh-tech project teams (e.g., Apollo moon landing project teams) employ technologies that do not exist at the project initiation phase. This type of project relies on assembling elites in related areas, aiming to make a difference and create the future. Team members require enormous amounts of communication to exchange information and identify problems.

With advances in communication technology, organizations are increasingly using virtual project teams to implement work (Bell and Kozlowski, 2002). Bell and Kozlowski (2002) differentiated virtual project teams from conventional project teams according to differences in spatial distance (distributed versus proximal) and communication media (technology-mediated versus face-to-face). They also proposed that virtual project teams are more likely to be self-managing teams in that leadership functions are constrained by distributed spatial distance and asynchronous communication media. Moreover, Bell and Kozlowski (2002) focused on four dimensions to distinguish different types of virtual project teams: temporal distribution, boundary spanning, lifecycle, and member roles. Along the four dimensions, they placed an "ideal type" of virtual project teams at one end, and a "conventional type" at the other end. The "ideal type" operates through asynchronous communication media, spans numerous boundaries (e.g., functional, organizational, cultural boundaries), disbands on the completion of the project, and consists of members with multiple team memberships. In contrast, the "conventional type" adopts synchronous communication media, spans fewer boundaries, develops a continuous lifecycle, and is composed of members with singular team membership. Furthermore, Bell and Kozlowski (2002) discussed relationships between interdependence and the four dimensions. They proposed that the more interdependent project team requires more synchronous communication media, less boundary spanning, a more continuous lifecycle, and more fixed team members.

2.3 Dimensional scaling approach

Although taxonomic classification has generated various categorization systems, researchers might have difficulties in applying them to their research, due to the "either/or" nature embedded in taxonomic classification, while researchers attempt to study what are actually continuous dimensions of project teams. To address this challenge, Nunnally (1978) proposed adopting ratio scales that can reflect variation along continuous dimensions.

Building on Nunnally's insight, we propose using first-order building blocks as key independent variables for studying second-order factors (Doty and Glick, 1994; Felin and Foss, 2009). This means that instead of focusing on the second order factors, i.e., taxonomies, we look into the first order factors upon which various taxonomies are constructed. We posit that the underlying dimensions that build different taxonomies could generate greater consensus on project team classification. (Doty and Glick, 1994; Hollenbeck et al., 2012). This particular way of classification is called dimensional scaling. Indeed, the above-reviewed literature on project team taxonomies all contained various dimensions beneath them. We found that they commonly shared seven dimensions as listed in Table 1.

Table 1. Definitions of team dimensions

Dimension	Definition	Existing literature
Skill differentiation	"The degree to which members have specialized knowledge or functional capacities that make it more or less difficult to substitute members" (Hollenbeck et al., 2012, p.84).	Ericksen and Dyer (2004), Hollenbeck et al. (2012), Levi and Slem (1995), Maznevski and Chudoba (2000). Scott and Einstein (2001)
Interdependence	The degree to which members depend on the contributions of others to complete tasks and goals (Scott and Einstein, 2000).	Katz (1982), Maznevski and Chudoba (2000), O'Connor et al. (2003), Pinto and Pinto (1997), Scott and Einstein (2001), White and Leifer (1986)
Authority differentiation	"The degree to which decision-making responsibility is vested in individual members, subgroups of the team, or the collective as a whole" (Hollenbeck et al., 2012, p.84).	Cohen and Bailey (1997), Henderson and Lee (1992), Hollenbeck et al. (2012), Scott and Einstein (2000), Uhl-Bien and Graen (1992)
Team size	A number of team members.	Espinosa et al. (2007), Kirkman and Mathieu (2005), Reagans et al. (2004), Taylor and Greve (2006), Zenger and Lawrence (1989)
Team longevity	Life span of a team.	Chiocchio and Essiembre (2009), Hollenbeck et al. (2012), Scott and Einstein (2000), Vashdi et al. (2013)
Virtuality	"The extent to which team members use virtual tools to coordinate and execute team processes, the amount of informational value provided by such tools, and the synchronicity of team member virtual interaction" (Kirkman and Mathieu, 2005, p. 700).	Furst et al. (2004), Jarvenpaa and Leidner (1999), Kirkman and Mathieu (2005), Powell et al. (2004), Rico et al. (2008)
Sharedness	The degree to which team members' "thought-worlds" are consistent with one another (Dougherty, 1987).	Alexander and Van Knippenberg (2014), Dougherty (1987), Kotha et al. (2013), Mathieu et al. (2007), Rico et al. (2008), Smith-Jentsch et al. (2008)

The definitions for each dimension are further elaborated as follows:

Skill differentiation. This dimension reflects the functional and demographic diversity of teams. Project team members are typically selected from different functional areas with complementary skills (e.g., Ericksen and Dyer, 2004; Levi and Slem, 1995; Maznevski and Chudoba, 2000; Scott and Einstein, 2001). Following Hollenbeck et al. (2012), we took a broader perspective on skill differentiation by including gender, age, education, work experience and any other factor where differentiation probably affects team performance.

Interdependence. It exists when a team member depends on others to accomplish project goals. The degree of interdependence is contingent on project types (e.g., Katz, 1982; Maznevski and Chudoba, 2000; O'Connor et al., 2003; White and Leifer, 1986). In the extant literature, various terms were used to describe the notion of individuals working interdependently, such as collaboration, coordination, cooperation, and integration (Pinto and Pinto, 1990). While these terms had distinct names, they referred to the same idea, i.e., interdependent behavior towards accomplishing a specific task (ibid.). According to this perspective, the interdependence dimension can be viewed as a broad dimension that includes collaboration, coordination, cooperation, integration, and other tasks and interpersonal relations when members jointly work toward project goals. Interdependence as understood here also encompasses both internal and external interdependence, since most works indicate that external interdependence is one of the most distinctive characteristics that differentiates project teams from other types of teams. This can be explained by the fact that project team members usually come from different departments and maintain interactions with home departments (Cohen and Bailey, 1997).

Authority differentiation. This dimension refers to the degree to which decision-making power is granted to team members. Low authority differentiation, in essence, means decentralization. The level of project team authority differentiation varies considerably (e.g., Cohen and Bailey, 1997; Henderson and Lee, 1992; Scott and Einstein, 2000; Uhl-Bien and Graen; 1992). For example, virtual project teams are more likely to be self-managing teams due to the challenge of monitoring and managing distributed team members (Bell and Kozlowski, 2002), while Japanese construction project teams tend to have high levels of authority differentiation due to their culturally-driven normative systems (Horii, 2005).

Team size. This is measured by the number of team members. Most prior research uses team size as a control variable in the analyses (e.g., Espinosa et al., 2007; Kirkman and Mathieu, 2005; Reagans et al., 2004.)

Longevity. This dimension can range from relatively short to longer terms. Project team members are usually disbanded upon completion of the project (Chiocchio and Essiembre, 2009; Hollenbeck et al., 2012; Scott and Einstein, 2000; Vashdi et al., 2013).

Virtuality. This is defined as "the extent to which team members use virtual tools to coordinate and execute team processes, the amount of informational value provided by such tools, and the synchronicity of team member virtual interaction" (Kirkman and Mathieu, 2005, p. 700). Based on this definition, any team can be described in terms of its virtuality (Rico et al., 2008).

Sharedness. This refers to shared team cognition (see Table 1. No.7), which when more strongly present facilitates team member congruity in how they make sense of their environment and enables the development of a shared vision for how to complete tasks and goals (Smith-Jentsch et al., 2008). Previous research identified several kinds of sharedness that had unique and interactive effects on team processes, emergent states, and outcomes (Rico et al., 2008), including shared team mental models (Mathieu et al., 2007), shared team situation models (Rico et al., 2008), sharedness of goal orientation (Alexander and Van Knippenberg, 2014), and shared knowledge (Kotha et al., 2013; Rico et al., 2008). These indicators of sharedness imply that sharedness should be viewed as a broad dimension that includes shared team mental models, shared situation models or any other kind of sharedness related to team performance.

2.4 Relationships among dimensions

Through reviewing the existing literature, we found that increasing the level of one dimension decreased (or increased) levels of other dimensions. For example, high level of skill differentiation was found to correspond to diminished levels of sharedness (e.g., Ancona and Caldwell, 1992b; Keller, 2001; Rico et al., 2008); team virtuality was increased when the project team sought to eliminate time and space barriers, but this strategy could decrease levels of both authority differentiation and sharedness (e.g., Powell et al. 2004; Kirkman and Mathieu, 2005; Maynard et al., 2012). Knowing the relationships among dimensions is important because it enables both researchers and practitioners to avoid unnecessary trade-offs among dimensions, and to minimize the costs entailed by necessary trade-offs. Table 2 summarizes the dimensional relationships found in previous studies.

Prior work indicates that the relationship between skill differentiation and authority differentiation could be positive in some cases and negative in other cases. For example, from a technical perspective, teams characterized by a high level of skill differentiation can have a low level of authority differentiation (e.g., Ericksen and Dyer, 2004; Jassawalla and Sashittal, 1999), as project managers in such cases are not as able to guide technically, evaluate, or supervise team members (Uhl-Bien and Graen, 1992). However, from a social perspective, high skill-differentiated teams can exhibit a high level of authority differentiation (e.g., Henderson and Lee, 1992; Levi and Slem, 1995), since professionals may lack social experience and thus need project leaders' guidance in handling interpersonal problems (Henderson and Lee, 1992).

The theory of shared mental models suggests that the relationship between skill differentiation and sharedness is negative (e.g., Cronin and Weingart, 2007; Newell et al., 2004). Project teams with a high level of skill differentiation were found to have difficulties in developing shared "thought-worlds" among team members (Dougherty, 1987) because there were representational gaps in the heterogeneous teams (Cronin and Weingart, 2007; Kotha et al., 2013).

The control theories have shown a positive relationship between interdependence and authority differentiation (e.g., Henderson and Lee, 1992; Levi and Slem, 1995; Sheremata, 2000). For example, for projects that require intensive interaction among team members,

Table 2. Relationships among Dimensions

Relationship (Independent dimension) (Dependent dimension)	Positive relationship (Citation)	Negative relationship (Citation)
Skill differentiation		
Authority differentiation	Henderson and Lee (1992), Levi and Slem (1995)	Ericksen and Dyer (2004), Jassawalla and Sashittal (1999), Uhl-Bien and Graen (1992)
Sharedness		Ancona and Caldwell (1992b), Cronin and Weingart (2007), Ericksen and Dyer (2004), Hutchins et al. (1990), Jassawalla and Sashittal (1999), Keller (2001), Maznevski and Chudoba (2000), Newell et al. (2004), O'Connor et al. (2003), O'Reilly et al. (1998), Rico et al. (2008), Zenger and Lawrence (1989)
Interdependence		
Authority differentiation	Henderson and Lee (1992), Levi and Slem (1995), Sheremata (2000)	Shremata (2000), Tushman (1979)
Virtuality		Kirkman and Mathieu (2005), Maznevski and Chudoba (2000)
Sharedness	Cummings et al. (2013), Maynard et al. (2012), O'Coonor et al. (2003), Takeuchi and Nonaka (1986), Wageman (1995)	
Authority differentiation		
Interdependence	Henderson and Lee (1992); Kim and Burton (2002), Langfred (2004), Sheremata (2000)	
Sharedness	Alexander and Van Knippenberg (2014), Furst et al. (2004), Kim and Burton (2002), Maynard et al. (2012)	
Size		
Skill differentiation	Taylor and Greve (2006)	
Interdependence	Reagans et al. (2004)	Reagans et al. (2004), Zenger and Lawrence (1989)
Authority differentiation	Furst et al. (2004), Scott and Einstein (2001)	
Longevity		Staats et al. (2012)
Sharedness		Espinosa et al. (2007)
Virtuality	Kirkman and Mathieu (2005)	
Virtuality		
Authority differentiation	Furst et al. (2004), Maynard et al. (2012), Powell et al. (2004)	Powell et al. (2004)
Sharedness		Cronin and Weingart (2007), Espinosa et al. (2007), Kirkman and Mathieu (2005), Maynard et al. (2012)

centralization plays an important role in managing interpersonal issues (Levi and Slem, 1995). However, the information processing perspective suggests that when the interdependence level among team members is high, decentralization is needed to speed up information integration

(Sheremata, 2000; Tushman, 1979). As the level of interdependence increases, team virtuality is likely to decrease (Kirkman and Mathieu, 2005). Because the more interdependent a project is, the more information-rich and synchronous communications need to be for carrying out the project effectively (Kirkman and Mathieu, 2005; Maznevski and Chudoba, 2000). Theories of shared mental models suggest a positive correlation between interdependence and sharedness (e.g., Maynard et al., 2012; O'Coonor et al., 2003; Takeuchi and Nonaka, 1986). A high level of interdependence represents a high degree of interaction and communication, encouraging team members to share information and develop common perspectives (Cummings et al., 2013; Wageman, 1995).

Compared to centralized teams, decentralized teams have a lower level of interdependence. This is partly because team members in decentralized teams have less motivation to exchange information (Henderson and Lee, 1992; Kim and Burton, 2002; Langfred, 2004) and partly because more links must be traversed in a decentralized team, which also hinders interdependent processes (Sheremata, 2000).

Previous analyses of leadership's influence on sharedness suggest that when the authority lies in the hands of project leaders, convergence in shared goal orientation may be quite common (e.g., Furst et al., 2004; Kim and Burton, 2002; Maynard et al., 2012). One of the reasons is that project leaders provide a clear direction for a team's sense-making and thus help the team to create a shared understanding of team missions (Alexander and Van Knippenberg, 2014; Maynard et al., 2012).

Meanwhile, size is an underlying dimension that correlates with all other six dimensions. Larger teams can complete projects more quickly (Staats et al., 2012). However, increasing a team's size creates problems such as hampering coordination, diminishing individual motivation, and increasing relational conflicts (Hoegl, 2005; Staats et al., 2012). Under such circumstances, a project leader needs to facilitate coordination, mobilize team members, manage conflicts, and assess rewards to ensure the accomplishment of project goals (Furst et al., 2004; Scott and Einstein, 2001). Some research suggests that as project-team size increases, the average amount and frequency of communication decreases (Zenger and Lawrence, 1989). Nonetheless, Reagans et al. (2004) found an inverted-U-shaped relationship between team size and interdependence. Team size initially has a positive effect on interdependence. When team size increases to about ten members, team size starts to be negatively related to interdependence (Reagans et al., 2004). When team size increases, the diversity of skills also increases (Taylor and Greve, 2006). As project teams grow larger, there are fewer chances for the whole project team to assemble for face-to-face meetings. As a result, larger project teams have more difficulty in developing a shared understanding (Espinosa et al., 2007). Moreover, members need to use more asynchronous communication in larger teams, increasing the level of team virtuality (Kirkman and Mathieu, 2005).

Shifting to the time dimension of teams, although there are a few studies on the correlation between team longevity and other dimensions (e.g., Furst, 2004; Katz, 1982; Kirkman and Mathieu, 1997; Rico et al., 2008), they focused particularly on the diachronic phenomenon, which is beyond the research scope of this paper. Instead, this paper directs the focus on the initial state of project team configuration. As a result, we excluded the diachronic studies and found almost no articles examining the correlation between team longevity and other dimensions.

Regarding virtuality, members in more virtual project teams have greater ability to diverge from traditional reporting requirements. They may consequently be granted higher degrees of autonomy (Powell et al., 2004). However, excessive autonomy creates conflicts and hinders team effectiveness in a virtual environment (Furst et al., 2004; Powell et al., 2004). Under these circumstances, managerial control mechanisms are important for minimizing conflicts and integrating the contributions of different members (Furst et al., 2004; Maynard et al., 2012;

Powell et al., 2004). Theories of shared mental models indicate that sharedness is adversely affected by virtuality because geographically distributed teams share a weakened teamwork context, and allow more divergent perceptions of norms to occur (Cronin and Weingart, 2007; Espinosa et al., 2007; Maynard et al., 2012). High levels of virtuality can also impair information value and synchronicity in team member communication (Kirkman and Mathieu, 2005). Consequently, virtual teams often experience difficulties in achieving a shared understanding of team tasks (Maynard et al., 2012).

Finally, we did not find research about the effects of sharedness on other dimensions at the initial formation state of project teams. It is possible that sharedness always acts as a dependent dimension that is influenced by other dimensions such as skill differentiation and authority (e.g., Alexander and Van Knippenberg, 2014; Ancona and Caldwell, 1992b; Rico et al., 2008). It is also possible that sharedness is an emergent dimension that develops through interaction and collective learning (Newell et al., 2004).

3. Developments and applications of the seven-dimensional scaling model

In this section, we illustrate how the 18 types of project teams discussed in the literature could be better presented using a seven-dimensional scaling model.

3.1 Project team types

Existing literature has studied different types of project teams. Specifically, we found 18 types of project teams used in research on the construction, education, and information technology industries. Using our seven-dimensional scaling model, we illustrate how these project teams could be better presented, as shown in Table 3.

Table 3. Types of construction project teams studied by previous scholars.

Team type	Level of dimension							Citation
	Sk	In	Au	Si	Lo	Sh	Vi	
1. Construction project team	3	3	1 ¦ 3	1 ¦ 3	1 ¦ 3	1	2	Baiden et al. (2006), Buvik and Rolfsen (2015), Fong (2003), Kivrak et al. (2008), Ospina-Alvarado et al. (2016), Robichaud and Anantatmula (2011), Xue et al. (2010), Zhang and Ng (2013)
2. CM/GC project team	3	3	3			1		Farnsworth et al. (2015)
3. DB project team	2	2	2			2		El Asmar et al. (2010), Farnsworth et al. (2015), Gransberg and Windel (2008)
4. BOT project team	3	2	3	3	3	1		Chan et al. (2005), Lu et al. (2010)
5. Infrastructure project team	3	2.5	3			1.5		Alashwal et al. (2016), Chen and Manley (2014), Gransberg et al. (2012), Liu and Leitner (2012); Van Os et al. (2015)
6. Megaproject team	3	3	3	3	3	1		Ahern et al. (2014), Brady and Davies (2014), Davies and Mackenzie (2014), Dietrich et al. (2013), Goh et al. (2012), Kwak et al. (2014), Patanakul et al. (2016)
7. Construction management team	3	2				1		Lee et al. (2012), Tennant et al. (2011)
8. Engineering project design team	3	2	2			1		Singhaputtangkul and Zhao (2016), Sprauer et al. (2015), Zhang and Cheng (2015)
9. On-site vs. virtual design team	3	2 v.s. 1	2 v.s. 3			1	1 v.s. 3	Grau et al. (2011)
10. Construction operative team	1	3	3					Mitropoulos and Memarian (2012), Tennant et al. (2011)
11. Ancient construction project team	2	3	3			3	1	Kozak-Holland and Procter (2014)
12. Multicultural construction project team	3		1 ¦ 3			1	2	Di Marco et al. (2010), Ochieng and Price (2010)
13. Geographically dispersed construction project team	3		1			1	3	El-Tayeh and Gil (2007)

14. BIM-enabled construction team		3				2	3	Bryde et al. (2013), Lu et al. (2015), Sun et al. (2015), Wu and Issa (2014)
15. Green project team	3	3	3			3		Azari and Kim (2015), Franz et al. (2013), Herazo et al. (2012), Korkmaz et al. (2010), Lapinski et al. (2006), Robichaud and Anantatmula (2011)

Note: Sk = Skill differentiation; In = Interdependence; Au = Authority; Si = Size; Lo = Longevity; Sh = Sharedness; Vi = Virtuality.
We use a three-point scale to represent the level of a dimension: 1 indicates low, 2 moderate, and 3 high. We use 1.5 to denote cases where low and moderate levels both exist, and 2.5 where moderate and high levels both exist; 1--3 indicates cases where low, moderate and high levels all exist.

Type 1: Construction Project Team

Construction project teams often involve a wide range of team members who come from different organizations and possess different expertise (Buvik and Rolfsen, 2015; Xue et al., 2015; Zhang and Ng, 2013). Differences in organizational culture and expertise can pose barriers to team sharedness (Baiden et al., 2006; Kivrak et al., 2008; Xue et al., 2015). High level of skill differentiation and low level of sharedness make construction project teams complex and difficult to manage. Management complexity and difficulty also arise from reciprocal interdependence among team members, including authorities, contractors, architects, engineers, and suppliers, etc. (Bryde et al., 2013; Pournader et al., 2015; Xue et al., 2010).

Construction project team size can range from small to large (Baiden et al., 2006; Buvik and Rolfsen, 2015). Team longevity can last from a few months to several years (Buvik and Rolfsen, 2015). Lack of previous experience working together on the same site is a regular construction challenge (Robichaud and Anantatmula, 2011). Though a decentralized management approach facilitates horizontal communication across disciplinary boundaries (e.g., Baiden et al., 2006), optimal and actual levels of authority differentiation are contingent on project types.

Type 2 and 3: CM/GC and DB Project Team

Farnsworth et al. (2015) compared construction manager/general contractor (CM/GC) teams with design-build (DB) project teams. Their research findings indicated that CM/GC project delivery allowed contractors to directly control the team, while DB project delivery made contractors lose control over project teams. CM/GC teams required a higher level of interdependence to manage disputes, claims, and end-of-project issues related to having numerous contractors (ibid.). Although an CM/GC approach induces greater cooperation in the project team, it also increased the number of people involved and the number of varying opinions (El Asmar et al., 2010; Farnsworth et al., 2015; Gransberg and Windel, 2008). According to the relationships between dimensions (see section 2), larger team size would lead to higher levels of skill differentiation and lower levels of sharedness. These relationships were validated in Farnsworth et al.'s studies.

Type 4: BOT Project Team

Build-operate-transfer (BOT) project teams have long-term lifecycles and large team sizes (Lu et al., 2010). With multiple participants, team members are significantly differentiated in business cultures, engineering fields, standards, etc., and thus have difficulty in developing shared objectives (Chan et al., 2005). To manage the risks associated with these diversified objectives and interests, BOT project teams adopt hierarchical management for executing, monitoring, and auditing construction work (Chan et al., 2005; Lu et al., 2010). BOT project participants interact regarding their interests (Chan et al., 2005). Given that large team size reduces interdependence among team members (Reagans et al., 2004), we rated the interdependence level of BOT teams as moderate rather than high.

Type 5: Infrastructure Construction Project Team

Infrastructure construction projects include highway, bridge, tunnel, water supply plant, waste treatment plant, and power plant construction projects. Teams for infrastructure projects have a multi-disciplinary composition of participants (Gransberg et al., 2012; Van Os et al., 2015). A project manager or a project management team has a high degree of authority to direct construction work (Chen and Manley, 2014; Liu and Leitner, 2012; Van Os et al., 2015).

Take highway construction project teams as an example to illustrate the characteristics of infrastructure construction teams in more detail. Alashwal et al. (2016) studied two highway construction project teams, both of which had a mixture of skilled workers, such as mechanical and electrical consultants, civil and engineer consultants, checkers for structure, and road safety auditors. By comparing the levels of sharedness and interdependence of the two project teams, Alashwal et al. (2006) found that higher levels of sharedness and interdependence contributed to better team performance.

Type 6: Mega Project Team

Megaprojects are defined as "projects that cost more than $1 billion, or projects of a significant cost that attracts a high level of public attention or political interests because of substantial direct and indirect impacts on the community environment and budget" (Patanakul et al., 2016, p. 453). The typical durations of megaprojects are over five years (Patanakul et al., 2016). The project size is so significant that multiple parties are involved to obtain a wide range of special expertise (Brady and Davies, 2014; Goh et al., 2012; Kwak et al., 2014). It is not unusual for different parties to have conflicting objectives (Brady and Davies, 2014).

Alongside high level of skill differentiation and low level of sharedness, the complexity of megaproject management also arises from a high degree of interdependence between parts (Ahern et al., 2014). For instance, the London Olympic construction megaproject was a complex system of multiple interacting parts, consisting of over 70 subprojects with great interdependence among them (Brady and Davies, 2014).

The authority differentiation characteristic of megaproject teams is a hybrid of centralization and decentralization. On one hand, a central management office is needed to respond to the complexities, uncertainties, and high risks involved in a megaproject (Patanakul et al., 2016; Brady and Davies, 2014). Findings from prior research suggest that lack of management control leads to poor megaproject performances (Patanakul et al., 2016). On the other hand, a megaproject is usually broken down into many subprojects, in which members may implement tasks with a non-hierarchical, less authoritarian approach (Brady and Davies, 2014; Guo et al., 2014).

Type 7: Construction Management Team

Construction management teams comprise of various professionals such as project planners, site manager, and construction manager (Tennant et al., 2011). Tennant et al's (2011) case studies showed that construction management teams required a high level of interdependence. Nonetheless, owing to different standards, specifications, business traditions and cultures, collaboration among participants was difficult and infrequent, and development of shared understanding was problematic (Lee et al., 2012; Tennant et al., 2011).

Type 8: Engineering Project Design Team

Engineering project design teams involve a wide range of experts (Zhang and Cheng, 2015). Case studies showed that design teams with higher interdependence were more successful (Singhaputtangkul and Zhao, 2016; Sprauer et al., 2015). Nonetheless, within the context of market economies, relationships among designers shifted from collaboration to serious competition (Zhang and Cheng, 2015). In addition to the competition, conflicting objectives among team members result in a low level of sharedness in design teams (Singhaputtangkul and Zhao, 2016; Zhang and Cheng, 2015). As for authority differentiation, Sprauer et al.'s (2015) analyses of 113 design teams indicated that the majority worked in neither of the extremes, but rather within a flexible regime of rules.

Type 9: On-site Design and Virtual Design Team

Grau et al. (2011) compared on-site design teams with virtual design teams (Table 3, type 9), and found that the latter required authoritarian management to help overcome cross-cultural diversity and communication obstacles.

Type 10: Construction Operative Team

Construction operative teams adopt more authoritarian management approaches to control workers (Mitropoulos and Memarian, 2012; Tennant et al., 2011). Construction work is always divided into subteams to perform different activities (Mitropoulos and Memarian, 2012). Within each subteam, workers have a similar skill base and significantly influence each other's performance (Mitropoulos and Memarian, 2012).

Type 11: Ancient Construction Team

Ancient construction teams employ a mixture of a skilled workforce (e.g., masons) and non-skilled workforce (e.g., laborers). This type of project team has clear lines of hierarchy. For instance, in the construction of the Florence Duomo by Filippo Brunelleschi in the fifteenth century, Brunelleschi was responsible for leading the project team, and he appointed eight master-masons to direct the workforce (Kozak-Holland and Procter, 2014). In addition to hierarchical management, high levels of interdependence and sharedness also contributed to the success of the Florence Duomo Project.

Type 12 and 13: Multicultural and Dispersed Construction Team

In contemporary society, globalization and technological advancements have led to an increasing use of multicultural construction teams and geographically dispersed construction teams. Multicultural construction team members come from different cultural and expertise backgrounds, and they work in adjacent sites. Globally dispersed construction team members also come from different expertise backgrounds, but they are geographically dispersed. Owing to cultural differences, multicultural team members often lack understanding about other teammates' views (Di Marco et al., 2010); owing to the high level of virtuality, geographically dispersed team members also lack shared understanding (El-Tayeh and Gil, 2007). When designing the level of authority differentiation, multicultural team designers need to take culture into account. For instance, American construction teams prefer a low level of authority differentiation, while Japanese teams prefer more strongly hierarchical authority differentiation

(Horii, 2005; Ochieng and Price, 2010). In geographically dispersed construction teams, a low level of authority differentiation is more appropriate for team management (El-Tayeh and Gil, 2007).

Type 14: BIM-enabled Construction Team

During the last decade, information and communication technology (ICT) development has led to the proliferation of Building Information Modeling (BIM) in the construction industry (Bryde et al., 2013). Compared to traditional construction teams, BIM-enabled construction teams (Table 3, type 14) show higher levels of interdependence, sharedness, and virtuality (Bryde et al., 2013; Lu et al., 2015; Sun et al., 2015; Wu and Issa, 2014), in that BIM facilitates information sharing among team members (Lu et al., 2015; Wu and Issa 2014).

Type 15: Green Project Teams

In recent years, green project teams are gaining momentum because of the increasing attention to construction sustainability (Franz et al., 2013; Korkmaz et al., 2010). Different from traditional construction teams, green project teams require intense interdisciplinary collaboration and additional consideration of green system design (Azari and Kim, 2015; Franz et al., 2013; Korkmaz, 2010; Lapinski et al., 2006; Robichaud and Anantatmula, 2011). Green projects always adopt a top-down approach to guide all phases of sustainable construction (Herazo et al., 2012; Robichaud and Anantatmula, 2011). To deliver a green project within limited costs and time, team members must have a clear and shared understanding of the sustainability goals (Herazo et al., 2012; Robichaud and Anantatmula, 2011).

Although the focus of the above discussion has been on the construction industry, we can also use the seven dimensions to analyze project teams in other industries, as shown in Table 4.

Type 16: Academic Research Project Team

In academic research project teams, there is no hierarchical reporting structure (O'Connor

Table 4. Types of project teams in other types of industries.

Team type	**Level of dimension**							**Citation**
	Sk	In	Au	Si	Lo	Sh	Vi	
16. Academic research project team	2.5	2.5	1			2.5	2	Cummings et al. (2013), O'Connor et al. (2003)
17. Agile project team	3	3	1	1		3	2	Conforto et al. (2014)
18. Virtual project team	2.5	2.5	1			1	3	Bourgault et al. (2008), Furst et al. (2004), Kirkman and Mathieu (2005), Lee-Kelley (2006), Malhotra et al. (2007), Maynard et al. (2012), Maznevski and Chudoba (2000), Powell et al. (2004)

Note: Sk = Skill differentiation; In = Interdependence; Au = Authority; Si = Size; Lo = Longevity; Sh = Sharedness; Vi = Virtuality.

We use a three-point scale to represent the level of a dimension: 1 indicates low, 2 moderate, and 3 high. We use 1.5 to denote cases where low and moderate levels both exist, and 2.5 where moderate and high levels both exist; 1--3 indicates cases where low, moderate, and high levels all exist.

et al., 2003). For the research project team, levels of skill differentiation and interdependence depend on the required degree of sharedness. When the project aims to arrive at a common theoretical perspective, it becomes essential to reinforce homogeneity and interdependence (Cummings et al., 2013; O'Connor et al., 2003). In contrast, when the project seeks to leverage heterogeneity for multidisciplinary research, levels of interdependence could be moderate or even low (Cummings et al., 2013; O'Connor et al., 2003). In many cases, the academic research team is geographically dispersed and is comprised of people from different institutions (Cummings et al., 2013). This implies that academic research teams can be characterized by moderate virtuality.

Type 17: Agile Project Team

The agile project team, derived from the software development industry, is becoming increasingly prevalent in all kinds of industries due to its agility in product development. The agility of the team can be attributed to such innovative measures as providing total autonomy to team members and maintaining active collaboration among team members (Conforto et al., 2014). Conforto et al.'s (2014) extensive studies on agile project teams indicated that there was a tendency to assemble small (84% of the cases), multidisciplinary (68% of cases), and virtual (89%) teams. In addition, Conforto et al. (2014) found that it was important for team members to have a shared vision of the project goal. Otherwise it was difficult for them to accomplish a project effectively.

Type 18: Virtual Project Team

Virtual project teams are widely used in all kinds of industries. Team members are geographically dispersed, yet they collaborate on interdependent tasks (Bourgault et al., 2008; Malhotra et al., 2007; Maznevski and Chudoba, 2000). Virtual team members not only differ in skills but also differ in cultural and organizational backgrounds (Bourgault et al., 2008). Research findings indicate that autonomy is an important characteristic for successful virtual teams (Bourgault et al.'s, 2008; Lee-Kelley, 2006), and sharedness is adversely affected by team virtuality and skill differentiation (Espinosa et al., 2007; Lee-Kelley, 2006).

3.2 A dimensional scaling model

Based on the seven dimensions and their interrelationships, we constructed a dimensional scaling model (Figure 1) to depict and compare project teams. The main dimensions - skill differentiation, interdependence, and authority differentiation – are represented by straight arrows. As the point, which represents a team, moves from the origin 0 upward along the arrows, each variable increases. Here we assumed that skill differentiation, interdependence, and authority differentiation are main dimensions of project teams. However, in different situations, the priority of the seven dimensions may be different. Therefore, the horizontal, vertical, and diagonal axes could be replaced by whatever three dimensions are contingently the highest priority in a given situation.

The secondary dimensions – virtuality and sharedness – are represented by curved arrows. The level of virtuality or sharedness would increase when the point moves along the arrow direction. Virtuality and sharedness are depicted as curved lines because their relationships with the three main dimensions are not linear. Nonetheless, these two curves could be represented by straight lines if desired.

The peripheral dimensions – size and longevity - are represented as the size and color shade of the point respectively. Specifically, a little point refers to a small team while a big point refers to a large team; light color denotes short team tenure while dark color denotes long

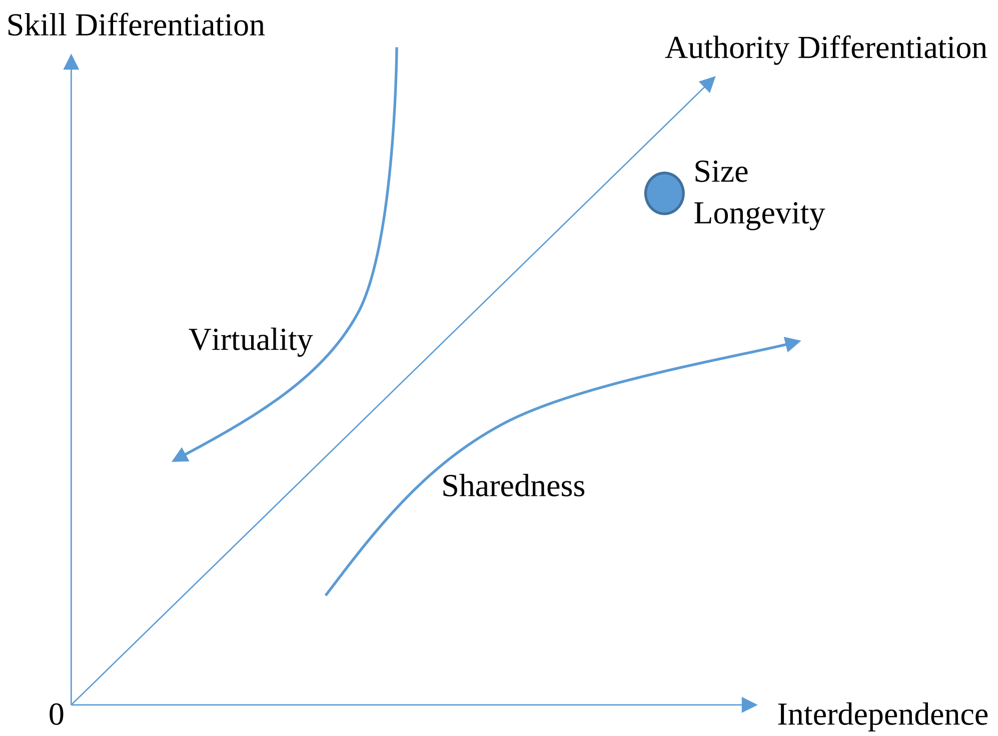

Figure 1. A dimensional scaling model for depicting and comparing project teams.

team tenure. These two dimensions represent basic configurations of a project team.

3.2.1 Depicting a project team

To depict a project team on the dimensional scaling model, the first step is to plot a point on the figure. This point displays basic team configurations, in that its size represents team size and its color shade represents team longevity.

After plotting a point with a specific size and color shade, the second step is to locate the point on the model. To pinpoint the location, it is necessary to figure out the levels of skill differentiation and interdependence. Using levels of skill differentiation and interdependence would derive a range of coordinate values rather than a single coordinate value because the levels of a dimension are represented as intervals (low, moderate, or high) rather than as a single value. For example, an on-site design team (Table 3, type 9) with high skill differentiation and moderate interdependence corresponds to a group of points as shown in the dashed area (see Figure 2).

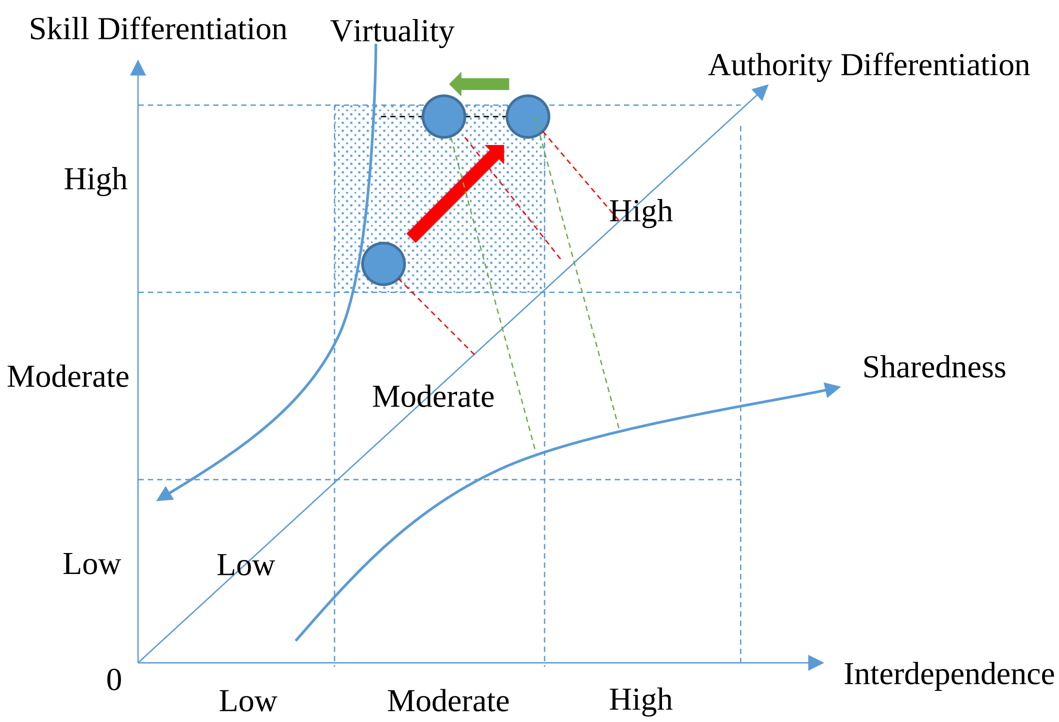

Figure 2. Steps for depicting a project team (e.g., on-site design team).

Based on the levels of interdependence and skill differentiation, step 2 narrows down team location to the scope of dashed area. The third step is to adjust the team location in the dashed area according to the level of authority differentiation. For this on-site design team example the level of authority differentiation is high. Hence, the point is moved up towards a high level of authority differentiation (see red arrow in Figure 2). This move shifts the level of authority differentiation from moderate to high (see the red highest dashed line perpendicular to the authority differentiation axis).

After leveraging the levels of three main dimensions to pinpoint team location, step 4 is to continue adjusting team position according to secondary dimensions, i.e., virtuality and sharedness. Still using the on-site design team as an example, the lines perpendicular to the virtuality and sharedness axes denote that the team's virtuality level is low (see the dark dashed line near and parallel to the top of the grid in Figure 2) and sharedness level is moderate (see the rightmost green dashed line in Figure 2). The level of virtuality is consistent with previous research findings, while the level of sharedness is in contrast with previous research findings. Therefore, the point is moved left along the dark dash line (see green arrow in Figure 2), a move that lowers sharedness level but does not change the virtuality level. Under the assumption that the authority differentiation dimension takes precedence over the sharedness dimension, the point would not be moved over a long distance to ensure that the team's level of authority differentiation is still high after moving.

This model can locate the 18 teams mentioned in section 4.1. The first 15 teams can be directly located on the model, while the last 3 teams can be located only when the direction of authority differentiation axis is reversed. The implication here is the model can be further adapted to fit characteristics and contexts of different project teams. Project team research and management may benefit further if researchers and practitioners adapt this model contingently when applying it.

3.2.2 Comparing project teams

Here we use on-site and virtual design teams (Table 3, type 9) as examples to illustrate how to compare project teams. The first step is to depict these two project teams on the dimensional scaling model following the procedures described in section 4.2.1 (Figure 3).

Step 2 is to draw perpendicular lines from the two points to each dimension axis. Note that there are two perpendicular lines from the virtual design team to the virtuality axis. Based on previous research findings, only the line that indicates a higher level of virtuality is reserved (see Table 3, type 9). Next, the model is contingently adapted through reversing the direction of the authority axis. This adaptation ensures that values denoted by the point fit observations in previous research (see Table 3, type 9), in which virtual design teams had a higher level of authority differentiation than on-site design teams.

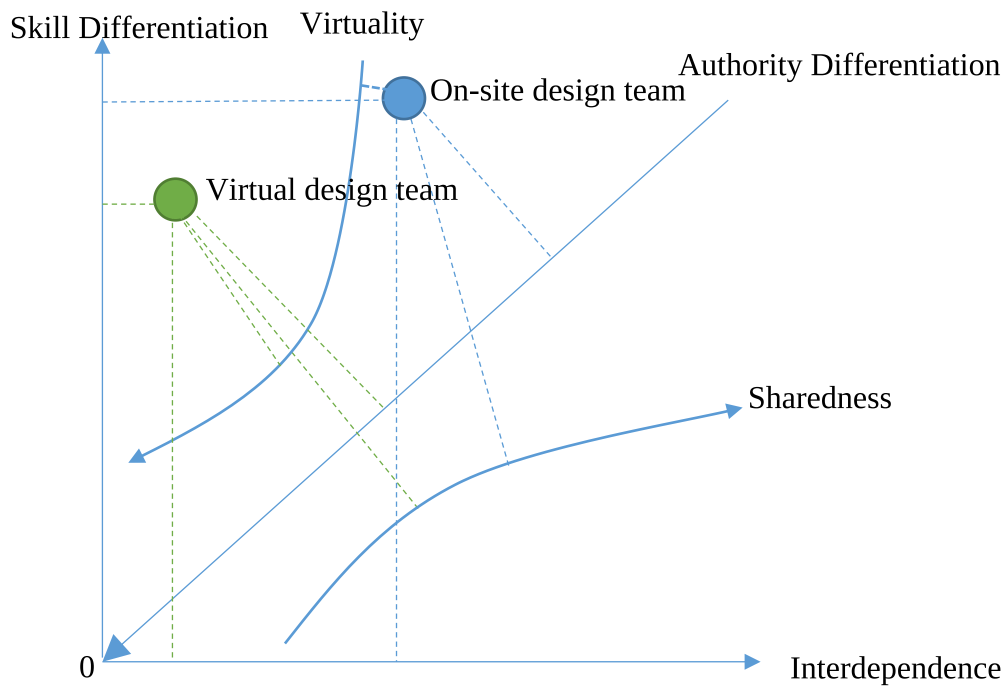

Figure 3. Comparison between project teams.

The final step is to compare team dimensions and analyze differences. Figure 3 shows that on-site design teams and virtual design teams are mainly different in levels of virtuality, interdependence, and authority differentiation. The former has a low level of virtuality, whereas the latter has a high level of virtuality. Research findings indicate that increasing the level of virtuality decreases the level of interdependence owing to liabilities (such as communication obstacles and integration problems) connected with virtuality, and thus a highly virtual team requires authoritarian management to overcome these liabilities (Furst et al., 2014; Grau et al., 2011; Maynard et al., 2012). As a result, virtual design teams have a lower level of interdependence and a higher level of authority differentiation than on-site design teams. There are also nuances in skill differentiation and sharedness, due to their interrelationships with virtuality, interdependence, and authority differentiation.

4. Implications

The dimensional scaling model provides many specific ways to improve knowledge accumulation, theory building, and managerial practice.

4.1 Knowledge accumulation

The model provides a consensual approach for describing the nature of a project team, in that all teams can be described in terms of the seven underlying dimensions. Such a consensual approach would promote knowledge accumulation. This model, just like GPS coordinates, enables researchers to position their particular teams in relation to existing team research. In other words, the "GPS coordinate" depicts different arrangements of a particular type of team, making it possible for aggregating and integrating results across research.

4.2 Interrelationship visualization

The dimensional scaling model offers a tool to visualize interrelationships among dimensions. Interrelationship visualization allows researchers to capture changes that may occur in a dimension and related dimensions. For example, with the development of information and technology, on-site design teams gradually evolve into virtual design teams. Under this circumstance, the virtuality level of design teams changes from low to high. Although virtual design teams can take advantage of high virtuality to expedite project schedules (Love et al., 2011), they suffer from low sharedness (Alashwal et al., 2006). That is to say, an increase in virtuality level leads to a decrease in sharedness level (see Figure 3). The reason is that virtuality impairs information sharing among team members (Kirkman and Mathieu, 2005).

4.3 Theory specification

The intertwining relationships presented in the dimensional model suggest that two or more dimensions may interact to influence team performance. This signals the researcher to consider moderator and mediator effects associated with the nature of the team. For example, Kotha et al. (2013) found that sharedness acted as a moderator in the relationship between skill differentiation and team performance. Teams with low sharedness performed much more poorly in situations of high skill differentiation than in situations of moderate skill differentiation (ibid.).

4.4 Magnitude estimation

The dimensional scaling model increases statistical power for estimating the magnitude of the interrelationship among dimensions, because it measures each dimension as a continuous variable. By estimating the magnitude of interrelationships among dimensions, team designers are in a position to assess the impact of different characteristic combinations of a particular team. As a result, they are able to avoid unnecessary trade-offs among dimensions and to minimize the costs entailed by the necessary trade-offs.

5. Conclusions and Future Directions

This paper provides a dimensional scaling model for describing and differentiating project teams so that researchers can define more exactly what kind of project team their studies are targeting. It first reviewed seven underlying dimensions of project teams and their relationships, and then explained how the 18 types of project teams discussed in the literature could be more effectively presented.

Although the dimensional scaling model can help improve knowledge accumulation, theory building, and management practice, the paper still has several limitations. First, the relationships between dimensions are based on findings of previous research. Some research suggests a positive correlation between two dimensions, while other studies indicate a negative correlation between the same two dimensions. Therefore, meta-analyses of the relationships between dimensions are needed in future research. Another limitation is that we subjectively rated the levels of project team's dimensions as low/moderate/high based on the existing literature. Empirical work is needed to validate these ratings. Third, we took a broad perspective on these dimensions by regarding each dimension as a class of dimensions. Thus, researchers could explore the underlying dimensions of project teams in more detail.

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