Transferring Collective Knowledge: Teaching and Learning in the Chinese Auto Industry

Zheng Zhao
Department of Corporate Strategy and International Business
University of Michigan Business School, 701 Tappan Street, Ann Arbor, MI 48109-1234
Email: **janezhao@bus.umich.edu**
Phone: 810.714.2923

Jaideep Anand
Department of Corporate Strategy and International Business
University of Michigan Business School, 701 Tappan Street, Ann Arbor, MI 48109-1234
Email: **jayanand@bus.umich.edu**
Phone: 734.764.2310

Will Mitchell
Fuqua School of Business, Duke University
Email: **Will.Mitchell@duke.edu**
Phone: 919.660.7994, Fax: 919.681.6244

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Abstract

This paper is a theory-guided exploratory study of teaching and learning strategies that firms use to transfer of collective knowledge between organizations. Collective knowledge is knowledge that is both tacit and embedded in intra-firm group activities. We first discuss the benefits of group teaching and group learning in transferring collective knowledge from a source community to a recipient community. Group teaching involves joint teaching effort by multiple members of the source community. Group learning occurs when members of the recipient community gain collective exposure to same problems and solutions. We then explore and expand the initial discussion by examining international R&D capability transfer in the Chinese auto industry, based on interviews at multiple ventures in China and the U.S.

Several results emerge from the study. Group teaching is more effective than individual teaching in helping recipients understand multiple dimensions of a source's collective knowledge and creating bridge networks, while group learning is more effective than individual learning for helping trainees integrate and synthesize their learning and re-embed it with their local context. Among four teaching-learning configurations, group teaching-group learning is the most effective transfer strategy for transferring collective knowledge. Individual teaching-individual learning transfers collective knowledge poorly, but can lay a foundation for more complex teaching-learning combinations by transferring individual and codified knowledge. Compared to group teaching-group learning, the sequence of group teaching-individual learning followed by individual teaching-group learning is a less costly but lengthier and less effective process of transferring collective knowledge.

Collective knowledge, which is knowledge that is both tacit and involves group-wide activities, provides a durable basis for competitive advantage of firms because it is difficult to imitate (Kogut and Zander, 1992; Spender and Grant, 1996). In addition to being difficult to imitate, though, the tactitness and group-embeddedness mean that collective knowledge is difficult for firms to transfer into new uses as they attempt to adapt and grow (Cook & Brown, 1999; Kogut & Zander, 1992; Spender, 1996). Recent studies have examined the intra-organizational spread of best practices (Gupta & Govindarajan, 2000; Kostova, 1998; Szulanski, 1996), cross-border transfer of R&D management practices among multinational firms' subsidiaries (Inkpen & Dinur, 1998), and inter-alliance partner transfer of know-how (Brewer & Nollen, 1998). Most such studies focus on how contextual constraints such as absorptive capacity, transfer intent, relational capital, and country-level factors affect the outcome of transfer activities. By contrast, few studies examine the actual mechanisms by which firms transfer capabilities. This issue is especially salient for transferring knowledge to firms in emerging economies, which require new business skills in order to compete effectively in global markets. This paper develops a framework based on teaching and learning mechanisms that facilitate the transfer of collective knowledge.

Our approach is a multiple case study, involving the transfer of R&D practices from American and European multinational enterprises (MNEs) to alliances with Chinese firms. The research combines deductive insights from prior studies with inductive findings from the cases. We first lay out the conceptual foundation by defining collective knowledge and discussing individual and group teaching and learning processes for transferring knowledge from source to recipient communities. The literature review draws from a wide range of research. Each literature by itself is not sufficient to identify and assess teaching and learning activities during collective knowledge transfer. Together, though, the perspectives provide guidelines for interview questions, while leaving sufficient latitude that unexpected patterns could take shape during the study.

The field investigations draw from twenty-six interviews at four ventures in Chinese auto industry, as well as thirty-one preliminary interviews at nine firms in China and the U.S. Several findings emerged with regard to roles and effectiveness of various teaching-learning combinations in transferring collective knowledge. We confirm our initial thoughts on the superiority of group teaching and learning as mechanisms for transferring collective knowledge. We also identify several detailed ways in which these mechanisms work in practice. We use these inductive insights to develop three sets of propositions that can seed future research.

COLLECTIVE KNOWLEDGE AND ITS TRANSFER

Our goal is to understand the effectiveness of inter-organizational transfer of capabilities that have a high degree of collective knowledge. *Capabilities* are the processes by which firms use physical and knowledge-based factor inputs to create goods and services (Richardson, 1972). By *inter-organizational transfer* we mean that a recipient organization adopts capabilities that a source organization possesses (Baum and Ingram, 1998). By *transfer effectiveness*, we mean the degree to which the recipient organization is able to use the capabilities for its own purposes, by replicating the source's capabilities and/or by adapting the capabilities to the recipient's context (Darr, Argote and Epple, 1995; Winter and Szulanski, 2001). Relevant dimensions of effectiveness include the cost, speed, and accuracy with which a recipient can accomplish a task that uses the transferred capabilities.

The concept of *collective knowledge* arises from the general discussion of knowledge contained within firms, where knowledge is a firm's stock of beliefs and skills (Spender and Grant, 1996). Management research has identified two salient dimensions of firms' knowledge: tacit versus explicit and individually-carried versus group-embedded (Cook et al., 1999; Kogut et al., 1992; Nonaka & Takeuchi, 1995; Spender, 1996). We follow Spender (1996) in referring to knowledge that is both tacit and embedded in intra-firm group activities as collective knowledge. Cook and Brown (1999) use the term organizational genres in a similar vein.

Collective knowledge relates to ideas in the knowledge-based view of organization. This perspective often considers organizational capabilities as the firm's ability to harness and integrate the knowledge of many individual specialists. Capabilities contain three types of knowledge: (1) individual specialist knowledge, (2) common knowledge held by all members of the organization, such as engineering language, engineering literacy, shared cognitive schema and framework (Fiol, 1994), and shared knowledge of using boundary objects to achieve better cross-functional coordination (Carlile, 2002), and (3) inter-personal knowledge, such as recognition of each other's knowledge domain (Grant, 1996; Wegner, 1987) and inter-personal coordination routines (Nelson & Winter, 1982) . From this typology, common knowledge and inter-personal knowledge are group-level knowledge, which is the first dimension of collective knowledge. The second dimension, as we noted above, is tacitness. Collective knowledge, therefore, is the tacit portion of the common knowledge and inter-personal knowledge elements of organizational capabilities.

Specific cases in which capabilities contain high levels of collective knowledge are common in practice. Team-based marketing programs that rely on un-codified understandings of customer needs are one example. Concurrent R&D management processes that jointly control timing, budgeting, and personnel movement, while incorporating market research, concept design, quality control, finance, purchasing, and manufacturing are another instance. Similarly, modern lean production systems that require coordinated activities and adjustments involving many people contain high levels of collective knowledge.

The group-tacit basis of collective knowledge contrasts with the other three general classes of knowledge that the tacit-explicit and individual-group dimensions define. The group-explicit combination involves scripted tasks that need to be conducted jointly, such as standardized maintenance programs. The individual-tacit combination involves individual employees who carry out unscripted activities such as personal sales calls. The individual-explicit combination involves independent employees who carry out scripted activities such as specific production line assembly tasks.

A firm's knowledge base includes all four knowledge combinations, but collective knowledge offers the most competitive advantage due the difficulty that other firms face in imitating skills that are both tacit and involve group-wide activities (Amit & Schoemaker, 1993; Dierickx & Cool, 1989; Penrose, 1959; Spender, 1996). However, the constraint is that in addition to being difficult to imitate, it is difficult for firms to transfer collective knowledge into new uses. Nonetheless, firms that overcome the transfer difficulties gain advantages when they expand into new areas, such as new or emerging markets.

Mechanisms required to transfer tacit knowledge have received most attention in prior research. Transfer of tacit knowledge benefits from stable and close contacts between the transferor and transferee. This commonly calls for the transferor and transferee to undertake joint projects, which facilitate close person-to-person contacts and learning-by-doing (Arrow, 1962; Brown & Duguid, 1998; Levitt & March, 1988; Nonaka et al., 1995; Polanyi, 1962). In order to transfer tacit R&D knowledge, for instance, both the source and recipient organizations often engage in joint R&D projects that serve as platforms for transferring capabilities that the firms cannot fully convey with verbal or written media (BIC, 1992). Nevertheless, learning-by-doing through joint projects is only a necessary condition for transferring collective knowledge, not a sufficient condition, because this mechanism alone does not resolve the difficulty of transferring group-embedded knowledge.

The key issue underlying the transfer of group-embedded knowledge is that the knowing entity of group-embedded knowledge is a community, rather than an individual or simple sum of individuals. Collective knowledge involves systems of coordinated relationships among members of the knowing community in which people interact to carry out routines or solve problems (Fiol & Lyles, 1985; Levitt et al., 1988; Nelson et al., 1982). Indeed, collective knowledge is partly independent of the individual members who execute the systems (Levitt et al., 1988; Nelson et al., 1982). As Cook and Brown (1999: 386) point out, "the body of [collective] knowledge is possessed by the group as a whole and is drawn on in its actions, just as knowledge possessed by an individual is drawn on in his or her actions". Together, then, the tacit and group-embedded aspects mean that transferring collective knowledge requires inter-communal learning-by-doing.

Two focal communities are relevant in the inter-communal process of transferring collective knowledge: the *source community*, which is the knowing entity of the targeted collective knowledge, and the *recipient community*, which is the knowing entity in which the collective knowledge will be re-embedded. Although firms can transfer some knowledge through vicarious imitation, recent research suggests that hands on teaching and learning processes enhance knowledge transfer (Darr, Argote, and Epple, 1995; Baum and Ingram, 1998; Argote and Ingram, 2000; Mitchell et al., 2002). The source and recipient communities serve as teachers and learners in the knowledge transfer process.

Group Teaching versus Individual Teaching

Teaching is the set of activities by which a knowledge source transmits knowledge. A source community can use different teaching mechanisms for transferring collective knowledge to the recipient community. We distinguish between two types of teaching strategies: group teaching and individual teaching.

The notion of group teaching is largely absent in management literature but related studies arise in the education literature. Education studies define team teaching as collaborations of teachers with different skills in a single classroom setting to simulate situations involving complex inter-personal interactions (Shaplin and Olds, 1964; Wenger and Hornyak, 1999). Here, in the business setting, we initially define group teaching as a process in which multiple teachers work together to explain the inter-relationships among the knowledge that they are teaching.

In contrast to group teaching, individual teaching uses individual members of the source community as teachers to instruct or supervise members of the recipient community at either the recipient location or the source site. In multinational cases, this commonly means that individual expatriates travel from the source to the recipient location.

Group teaching offers advantages for transferring collective knowledge. Groups of teachers will be better able to describe or demonstrate a source community's common knowledge and inter-personal knowledge, while helping students observe and interpret the institutional contexts that shape the knowledge, than will individual teachers. Individual teaching by members of the source community often struggles to bring collective knowledge to the recipient community. As Teece (1986: 20) notes, "…it will often not suffice to transfer individuals [to transfer collective knowledge]. While a single individual may sometimes hold the key to much organizational knowledge, group support is often needed, since organizational routines may need to be transferred." Nonetheless, firms often adopt individual teaching for transferring collective knowledge, such as posting individual trainers on international assignments.

Group Learning versus Individual Learning

Learning is the set of activities through which a recipient assimilates knowledge. Learning in a recipient community can happen at two different levels: group and individual (Inkpen, 1997; Tiemessen, Lane, Crossan, & Inkpen, 1997).

We use a preliminary definition of group learning as a process in which members of the recipient community gain collective exposure to same problems and solutions. Group learning by the recipient community may occur while the source community engages in either group teaching or individual teaching. Group-level learning requires adapting and embedding individual-level skills into group-wide routines, norms and rules within the recipient community (Araujo, 1998; Lave & Wenger, 1991; Levitt et al., 1988). Group learning implies developing consensus in cognitive frames (Fiol, 1994) and cultivating mutual understanding of each other's knowledge domain (Ellis, Hollenbeck, Ilgen, & Porter, 2002; Grant, 1996; Wegner, 1987).

We define individual learning as a process in which members of the recipient community learn skills as individuals. In contrast to group learning, individual learning often occur when recipients do not work together to share their learning with each other, whether they learn at the same time or location or not. The notion of individual learning is similar to Kasl et al.'s (1997) definition of the fragmented mode of team learning, in which individuals learn separately even though they may be in the same teaching environment, such that the group does not gain a holistic understanding of what the individuals have learned.

In parallel with group teaching, group learning offers advantages for transferring collective knowledge to recipients. Just as collective knowledge involves shared processes at the source organization, learners must create a set of shared knowledge that they will need to embed within the recipient community. (Kasl, Marsick, & Dechant, 1997) note the importance of synergetic team learning, in which members create knowledge mutually and integrate divergent perspectives by creating shared meaning schemes.

Nonetheless, many firms adopt individual learning for inter-organizational knowledge transfer (Liebrenz, 1982; Reddy & Zhao, 1990). Most technology transfer agreements, for instance, state the provisions for training members of the recipient organization in measures such as person-months of on-site training, without requirements for cooperative education (Reddy & Zhao, 1990).

Combinations of Teaching and Learning Strategies

Previous studies of knowledge transfer mostly focus either solely on teaching or learning. We believe that it is useful to study teaching and learning strategies jointly as related aspects of knowledge transfer events, because every knowledge transfer practice involves a source and a recipient, that is, involves both teaching and learning strategies. Based on the interplay of the teaching and learning dichotomies we discussed above, we develop a two-by-two matrix of teaching-learning strategies. Table 1 describes the four teaching-learning configurations.

******** Table 1 about here ***********

The preceding discussions of teaching and learning suggest that collective teaching and learning are superior to individual teaching and learning for the transfer of collective knowledge. Integrating these conclusions, we begin with the expectation that a combination of group teaching and learning is more effective for transferring collective knowledge than individual-group combinations which, in turn, are more effective than a combination of individual teaching and learning. Our research goal is to explore the finer-grained issues that determine the application and effectiveness of teaching-learning configurations.

RESEARCH SETTING AND METHODS

We base the study on interviews with managers in the Chinese auto industry who have taken part in knowledge transfer activities involving North American and European multinational motor vehicle manufacturers. This setting offers several strengths for this study. First, auto R&D management includes substantial collective knowledge. We believe that the results concerning collective and non-collective knowledge in this setting will generalize to other business activities, such as production. Second, there is growing incidence of transferring R&D practices from MNEs to Chinese-based auto facilities. Chinese technology policy has required R&D capability transfer in the joint ventures that MNEs form with local firms, while the MNEs have competitive incentives to develop technical capabilities at their local affiliates. Third, evidence from preliminary fieldwork suggested substantial variation in cross-case choices of collective knowledge transfer mechanisms. Fourth, there are substantial cultural, technical, and managerial differences between recipient organizations in China and MNE source units (Beamish, 1993; Child and Yan, 2001). Fifth, the use of a single industry helps control for industry-level factors, although we expect generalizability of the conclusions to go beyond this industry setting because the constructs are not industry-specific.

Collective knowledge transfer has been critically important in the industry. R&D unit of Chinese state-owned auto firms typically did not develop entire vehicle platforms for decades during the era of central command economy. The R&D organizational structures, product development procedures, and the R&D planning were highly inefficient and obsolete until these firms partnered with foreign companies and started to acquire modern R&D capabilities. Chinese engineers and managers not only had to learn individual skills, but more importantly, they needed to understand the tacit and group-embedded R&D mindset and routines of their foreign partners, and adopt them in their own context. This industry makes a strong case for learning, while providing similar cross-case contextual settings.

The multiple case study research approach suits our setting. The approach is appropriate for research that poses "how" or "why" questions. This method can be especially revealing for knowledge-based research topics, because of its ability to reach the depth and cover the breath of managerial intentions and mechanisms related to organizational resources and capabilities (Almeida & Grant, 1998; Brewer et al., 1998; Capron & Mitchell, 1999; Inkpen et al., 1998; Leonard-Barton, 1992; Rouse & Daellenbach, 1999).

Case selection of this study derived from three principles: (1) theoretical sampling, i.e., choosing cases that will help extend theory, rather than provide statistical randomization (Eisenhardt, 1989), (2) obtaining variance in constructs (Yin 1994), and (3) capitalizing on personal relationships between the first author and respondents to ensure interview access and data quality (Inkpen, 1997).

We collected data in two stages. During the first stage, in summer 2000, the first author conducted a field study involving open-ended interviews with thirty-one respondents from nine companies operating the Chinese auto industry. The purpose of this stage was to understand the context, as well as develop initial framing for constructs and relationships.

The second stage was an in-depth case study at four of the ventures, in summer 2001, focusing more explicitly on the four teaching-learning combinations. We administered semi-open questions with twenty-six different respondents from the four companies. Each interview section, which took place in Mandarin, lasted from two to five hours. We verified the case write-ups with the respondents and asked clarifications by telephone. Each of the four companies had conducted multiple R&D capability transfer events involving collective and non-collective knowledge, and applied all four combinations. Among these four companies, two are OEM joint ventures (Shanghai-Volkswagen and Beijing Jeep), one is a set of auto component joint ventures (Delphi-China), and the other is an R&D joint venture (PATAC). Table 2a summarizes the companies.

******** Table 2a here ***********

All respondents in the second stage of this study work for Chinese recipients of the R&D capability transfer. Respondents from the recipient community had a deep understanding of their firms' learning needs and results. In addition, the recipient respondents had substantial knowledge of the source firms because they typically had received training at source facilities. Thus, they could provide credible information about teaching and learning because they were observers of teaching as well as learners. Moreover, our earlier discussions with members of the source communities provided information about both teaching and learning, finding substantial convergence with the recipients' views.

Each interview in the second stage of this study followed the same four-part protocol to ensure reliability. First, the interviewer explained the purpose of the research, to ensure that the respondents understood the key concepts. Second, the respondent provided personal background and her/his perception of the development and status of R&D capabilities of the company. Third, the respondent provided detailed chronologies of particular R&D project(s) he/she participated in that involved transferring R&D capabilities from the source community to the recipient community. Fourth, the interviewer asked more specific and probing questions to acquire the respondent's personal opinions about knowledge transfer strategies with regard to the effectiveness of transferring the collective knowledge involved in R&D capabilities. The interviewer took notes during the conversations and then transcribed the notes within 24 hours.

The R&D projects emphasized intermediate- and final-stage R&D (Buckley & Casson, 1976). Most of the projects involved modifying styling to meet local tastes or modifying peripheral component design based on the vehicle platform designed by the source partner, in order to adapt local road conditions, safety, and environment regulations. The projects included a range of knowledge characteristics. Some projects focused on individual and/or explicit skills, such as use of CAE workstations and design software. Other projects encompassed collective knowledge, such as architectural knowledge, group-embedded R&D procedural knowledge, and product-specific design language. Although most local R&D does not involve full-scale auto platform design (a platform usually takes billions of dollars to develop and requires a volume of over one million vehicles a year to offset the research cost), the work involves many stages of R&D from market research to concept design to prototyping and validation. Thus, many of the R&D capabilities that firms want to transfer to the local operations contain collective knowledge.

A Chinese senior product development manager in Shanghai-Volkswagen described what R&D capabilities mean from the perspective of Chinese R&D managers:

> "R&D capabilities from my perspective include how to translate initial design ideas from marketing research into a systemic product design proposal, which guides the various tasks, timelines, budgeting and specifications for different function groups and coordination among these groups. R&D capabilities also imply how effectively we implement the product design proposal at various stages of the design process. A large part of these capabilities lies in the experience of managers and engineers."

We used multiple data collection methods, including face-to-face interviews, field observations, telephone interviews, and secondary sources of information about the company and their R&D projects. At each site, we interviewed multiple respondents ranging from engineers to senior managers to allow multiple perspectives on the same cases of R&D capability transfer (Table 2b provides details). The respondents have extensive experience with multiple R&D capability transfer events and all four knowledge transfer strategies. This experience is especially valuable because it permits the respondents to compare various strategies their firms used to transfer R&D capabilities.

******** Table 2b here ***********

Data analysis consisted of multiple readings of the interview transcripts and related documentation, and coding and identifying activities and subjective evaluations pertaining to different knowledge transfer strategies and teaching-learning configurations (Strauss & Corbin, 1990) . We pay particular attention to the following aspects of the interviews: (1) how respondents described details of knowledge transfer activities they engaged in, (2) what knowledge transfer strategies they perceived as effective or ineffective, (3) what particular benefits of transfer strategies the respondents deemed effective, (4) how respondents compared various knowledge transfer practices, and (5) the sequence of knowledge transfer activities involved in the chronologies that the respondents described, along with the rationale behind the sequence. The analysis generated a set of recurring themes. We developed three sets of propositions based on these inductive findings.

In order to serve our research purpose of understanding various teaching-learning strategies, we take the individual knowledge transfer practices that involve the use of one teaching-learning strategy as the unit of analysis. For two reasons, we rely primarily on subjective evaluation when comparing teaching-learning strategies. First, an initial finding of our field study is that all firms we studied used multiple teaching-learning strategies to achieve their knowledge transfer objectives. Therefore, it is inappropriate to use the overall success or failure of the knowledge transfer initiatives to evaluate the effectiveness of individual knowledge transfer strategies or teaching-learning combinations. Second, factors other than the selection of knowledge transfer strategies, such as the firms' marketing strategies and financial positions, also influenced the outcome of the knowledge transfer initiatives. Using subjective comparisons of various transfer strategies by individual interviewees helps control factors that do not relate directly to teaching and learning strategies. To help ground the discussions, Table 2a reports several aspects of available objective data.

FINDINGS AND PROPOSITIONS

Teaching Strategies

The respondents in our study found that the distinction between individual and group teaching was meaningful. They also provided an additional dimension of group teaching. The teachers must provide their students with access to the source community's working environment, with opportunities to engage in applied projects. As we note below in greater detail, such involvement helps learners understand the context and nuances of ideas that their teachers are explaining. The discussions led us to refine the definition of group teaching, as a process in which multiple teachers work together to teach trainees in the source's working environment.

An example from Delphi-China helps demonstrate why using multiple teachers is only the beginning of group teaching. The joint venture assigned several U.S. engineers to teach Chinese engineers who traveled to Delphi's home base in the U.S. for three-months of in-class training. During the training, although many Delphi experts provided the Chinese trainees with instructions, the sessions often did not provide access to the day-to-day working environment of the source community, which limited the information that the teachers were able to provide.

All of the four firms we studied have used group teaching by sending Chinese trainees to either the home site of their foreign partners or the site of foreign partner's affiliates for on-the-job training with teams of foreign engineers, with the intent of acquiring design capabilities. Two firms also used a less common form of group teaching that involved teams of expatriates traveling from the foreign partner's home site to manage and train local staff, while replicating elements of the source working environment at the partner's site. All four firms had also used various forms of individual teaching.

When asked to compare the effectiveness of group and individual teaching for transferring R&D capabilities that involves high levels of tacit group-embedded knowledge, respondents from different companies converged on the superiority of group teaching. We used an open coding process (Strauss et al., 1990) to identify six advantages of group teaching over individual teaching. (1) Members of the recipient community can understand the shared mindset of the source community, where shared mindsets are common ways of making sense of information. (2) Members of the recipient community can observe organizing principles and organizational structures that the source community uses to perform certain tasks. (3) Members of the recipient community can observe how members of the source community carry out un-codified routines within functional areas. (4) Members of the recipient community can observe how members of the source community carry out un-codified routines across functional areas. (5) Members of the recipient community can identify which parts of the collective knowledge are idiosyncratic to the source community's context before they attempted to transfer that knowledge back to the recipient community. (6) Members of the recipient community can develop a trust-based network with multiple members of the source community and knowledge of who does what the best among them. We refer to this cross-community network as a *bridge network*. Table 3 provides examples.

******** Table 3 here ***********

A benefit of group teaching is that a group of people from the source community can work together to demonstrate to people from the recipient community key elements of R&D capabilities that are both tacit and embedded in the interactions of the members of the source community. Although knowledge recipients can understand the codifiable part of R&D capabilities through individual teaching or written documentation, they will not gain the richness and depth that they garner from being exposed to the source community's working environment. Many respondents mentioned that, within R&D capabilities, the aspects of knowledge that individual teachers can teach is only the tip of the iceberg.

A Chinese manager in the product development area of Shanghai-Volkswagen who participated an overseas on-job-training program commented:

> "At the beginning, we did not know a lot about Volkswagen's R&D process, we encountered a lot of difficulties in the learning process. What were written in the training materials and operation manuals are not detailed enough to cover all possible situations in the design process. And even if the written procedures cover everything, each German engineer seems to have his own personal way in interpreting these procedures. What we really need to learn is not the procedures, but the way of interpreting and applying them. This type of knowledge would be impossible to obtain had we not come to Volkswagen and worked with German engineers on a daily basis."

In practice, firms sometimes use individual teaching rather than group teaching and achieve a limited degree of collective knowledge capability transfer. Our argument is that group teaching leads to more thorough and effective transfer, such that a recipient community can accomplish a task that uses the transferred capabilities with greater speed, greater accuracy, and/or lower cost than individual teaching achieves. The following proposition highlights aspects of collective knowledge transfer that group teaching facilitates.

> **Proposition 1a.** Group teaching is more effective than individual teaching in helping recipients understand multiple dimensions of a source's collective knowledge, including shared mindsets, organizing principles and organizational structures, tacit within-function and cross-function procedural knowledge, and context-specific aspects of collective knowledge.

As we noted above, the fieldwork provided a further implication concerning the long-term impact of teaching processes. In addition to the immediate transfer of collective knowledge, the interviews revealed that group teaching helps create an inter-communal bridge network between the source and recipient communities during the teaching process. Bridge networks help facilitate ongoing transfer of both individual and collective knowledge.

A bridge network differs from an alternative communication mechanism, which relies on inter-communal boundary-spanners. Boundary spanners are strongly linked to their colleagues and have extensive links outside their subunits (Tushman & Scanlan, 1981). They provide a person whom members of the recipient community can contact in order to connect with relevant experts of the source community. In the cross-border cases that we studied, a boundary spanner is usually an expatriate from the source community who has broad relations with various experts in the source community and works in the recipient community either as a manager or as a trainer. A bridge network differs from a boundary-spanning individual in its flatness and short path distance between the person who holds the knowledge and the person who inquires about the knowledge. With a bridge network, members of the recipient community can form direct ties with experts of the source community, rather than go through the boundary spanner.

A bridge network often is superior to boundary spanners for the ongoing transfer of collective knowledge both because it is structurally flatter and shorter in path distance, but also because its ties are supported by stronger inter-personal personal trust and optimized by know-who developed during the group teaching process (Ahuja, 1996; Uzzi, 1996). Moreover, bridge networks help recipients engage multiple contacts at the source, which helps transfer group-embedded collective knowledge.

Organization scholars have long argued that key individuals are more cost effective than widespread communication across organizational boundaries (Arrow, 1974; March & Simon, 1958). With the help of information technology that facilitates ongoing contact, though, a bridge network may become even more cost effective than boundary spanners. As the net benefit of flat communication over indirect communication becomes more significant, organizations become flatter internally and so do inter-communal boundary spanning infrastructures.

Nonetheless, boundary spanners play valuable roles in knowledge transfer. In particular, boundary spanners provide access to people who do not fall within a recipient's bridge network. Thus, there are benefits to creating both ongoing communication mechanisms, which will tend to happen at firms that use both cooperative and individual teaching mechanisms.

> **Proposition 1b.** Group teaching is more effective than individual teaching in establishing bridge networks, which provide direct communication channels between members of the source and recipient communities. In contrast to group teaching, individual teaching fosters individual boundary spanner infrastructures, which create indirect communication channels.

Learning Strategies

Learning strategies address how recipients share and assimilate the knowledge that they have been taught with each other and, ultimately, with the recipient community. The respondents recognized the distinction between integrated and individual learning. They also brought up two important aspects of group learning in practice: *contemporaneous learning* and *intense interaction* among trainees during the training process.

Contemporaneous learning means that trainees learn together at the same time or in a short time interval, and thereby can observe and interpret similar information and reduce knowledge diffusion friction that arises from asynchronous learning. The interviews revealed that if trainees went for overseas training at different times, there would be instances when people who had received training needed to work with people in the recipient community who had not received training. Although such cases might appear to be opportunities to transmit new knowledge, many respondents complained about the difficulty of sharing knowledge when this happened. People who had completed overseas training commonly found it difficult to diffuse their new ideas into the rest of the recipient community, in which people had not acquired the mental framework that would help them understand the new knowledge. If several engineers and managers undertake the training at the same time and work together on the same projects, they are more likely to gain group-level knowledge through their interaction with each other. This helps reduce knowledge diffusion friction that arises from asynchronous individual learning.

> A Chinese manager from one of the firms we studied noted: "The reason that we haven't achieved the level of R&D capability that we should have achieved after so many years of effort is that we didn't cultivate the 'team mindset' about R&D among all engineers and managers. When those who have been trained overseas came back, they usually found that it was difficult to diffuse what they learned to their Chinese colleagues who had not gone overseas. Some aspects of R&D management cannot be communicated and promoted unless everyone understands the logic behind them."

Intense interactions among members of a recipient community, meanwhile, create a shared understanding of what they are learning. In particular, learning as a group of individuals does not necessarily mean group learning. All the companies we studied sent groups of their employees for in-class training or seminars for engineering or managerial courses, but training as a group did not result in group learning simply because several students sat together in the same classroom. Instead, the interviews suggested that the students must interact with each other during the learning process in order to develop a shared understanding of what they were learning in the classroom. The discussions led us to refine the definition of group learning, as a process in which trainees learn together as an interactive group.

Shanghai-Volkswagen's overseas training project provides a clear example of group learning. In this project, Chinese trainees not only worked in the unit of their specialty in Volkswagen with the teams of German experts (group teaching), but also communicated frequently with the other Chinese trainees (group learning). The group learning activities included coordinating problems from adjacent functions in the R&D process, as well as working on systemic R&D issues such as vehicle design data structures and body/exterior parameters that affect the dimensions and mounting locations of sub-assemblies and components. Besides the formal job-related interactions during the work time, the Chinese trainees in the Shanghai-Volkswagen program interacted with each other informally to share their learning and discuss problems after work hours. Living in the same apartment building, coming from the same cultural background, and speaking the same mother tongue promoted the informal interaction among

Chinese trainees. To enhance the group learning during the overseas training, the Chinese trainees also organized weekly meetings, to review what each one had learned in that week.

One Chinese trainee explained the situation as follows, while noting that the interaction and practices continued long after the formal training program ended.

> "We share knowledge learned and help each other to understand things from different perspectives. We discuss especially how German engineers interpret situations and solve problems, in other words, the things that are not written in manuals. The discussion among us really helped me to understand my part of the business and what my Chinese colleagues are doing in their parts of business."

All firms in our study used individual and group learning. The discussions identified several benefits of group learning over individual learning for transferring collective knowledge. We categorized these benefits into the following five areas. (1) Members of the recipient community develop a shared mindset. (2) Members of the recipient community understand the division of labor, coordination, and alignment of individual tasks. (3) Members of the recipient community understand who does what within the community. (4) Members of the recipient community develop coordination routines, thus creating a collective memory. (5) Members of the recipient community re-embed individual learning with their local context. Table 4 provides examples.

******** Table 4 here ***********

We conclude this section with the following proposition, which highlights aspects of collective knowledge transfer that group learning facilitates.

> **Proposition 2.** Group learning is more effective than individual learning for helping trainees develop a shared mindset, understand division of labor, identify who does what within a community, develop coordination routines, and re-embed individual learning in the recipient community.

Teaching-Learning Combinations

From the findings that group teaching and group learning are superior to individual teaching and individual learning in transferring collective knowledge, it is natural to project that the group teaching-group learning combination is superior to all other teaching-learning combinations, and therefore should be the dominant teaching-learning configuration firms use to transfer collective knowledge. However, to our surprise, we found that firms in our study used all four teaching-learning combinations to acquire and develop R&D capabilities.

Take Beijing Jeep, for example. During the 17 years prior to the interviews, the company used many types of teaching and learning to train vehicle design engineers for the joint venture.

The first type is overseas on-job training of teams of design managers and engineers with specific design projects, which can apply either for entire vehicle design or component design. The number of Chinese engineers in each training team ranged from 3 to 10 persons, with the length of each training section spanning from 3 months to over a year depending on the size of the project. This approach falls into the group teaching-group learning category. The second type of training is overseas formal engineering education. In Beijing Jeep's history, two batches of eight Chinese engineers received a one-year college-level engineering training from General Motors Institute (now, Kettering University). This is an individual teaching-individual learning combination. The third type of training involved sending individual engineers or managers to work full time as resident-engineers in the home base of the American partner for as long as a year. Eight Chinese employees received this type of assignment. This is a group teaching-individual learning combination. In recent years, overseas training has fallen rapidly. Instead, Beijing Jeep design engineers worked as a team under the supervision of individual foreign and local R&D managers to design several off-road vehicles that suit the Chinese market. This fits the category of individual teaching-group learning. Through all these approaches to training, the knowledge recipients obtained some degree of individual and collective knowledge of vehicle design and then re-embedded the knowledge in the Beijing Jeep R&D department. However, the interviews suggested that the group-group combination provided the most effective means of transferring collective knowledge.

In the following section, we will discuss the practical applications and subjective evaluations of different teaching-learning combinations that arose in the study. We also attempt to answer to two questions: (1) Why do firms use combinations other than group-group to transfer collective knowledge? (2) Can firms transfer any collective knowledge when group teaching-group learning is not the dominant mode?

Individual teaching-individual learning

Among the four teaching-learning combinations, individual teaching-individual learning is the base option, which all firms use routinely. Our cases indicated two general categories of individual teaching-individual learning: in-class training and one-on-one apprenticeship.

The firms used in-class training in various locations, such as in-house training centers, overseas training facilities, and independent training institutions. For example, Shanghai-Volkswagen developed an in-house training center soon after its establishment with German investment of 1.63 million Marks and Chinese investment of 2 million RMB. The training center sent 10 Chinese instructors to Volkswagen's training department. By 1998, 1,060 Chinese personnel from Shanghai-Volkswagen had received technical training from the training center.

One-on-one apprenticeships arose in both the source and recipient communities. In source communities, knowledge recipients often underwent one-on-one overseas training with a designated mentor. In recipient communities, expatriates from the source community often instructed and worked with knowledge recipients on an individual-to-individual basis.

Although various forms of individual teaching-individual learning arose in all cases we studied, the discussions found that individual teaching-individual learning alone does not achieve the same extent of collective knowledge transfer as combinations that involve group teaching.

> A design engineer from Delphi's joint venture noted: "We went to Saginaw for intense three-month in-class training. During that time, we learned a wide variety of courses from quality systems, marketing, and purchasing to manufacturing, design, and project management. These courses are important but we could not build our engineering capability based only on that after we came back to China. So, we went back to the U.S. for on-the-job training. This time, we not only worked in a real working environment, but also worked on a real project – a project related to our joint venture. I cannot begin to tell you how much more we have learned from our second training [than the first one]."

Although individual teaching-individual learning alone cannot fully transfer collective knowledge, it does not mean individual teaching-individual learning is not useful. In fact, individual teaching-individual learning is capable of transferring codified individual knowledge through in-class teaching, and tacit individual knowledge through apprenticeship. Acquiring individual-level knowledge helps build basic engineering concepts, communication ability and absorptive capacity for further learning of group-level knowledge. Therefore, individual teaching-individual learning helps prime other teaching-learning strategies.

> A manager of PATAC's training department noted: "Before we send the trainees to abroad to gain engineering knowledge, they have to involve/participate lots of basic training activities not only local but also in-class, such as cross-cultural issues (in-house). Function departments and training depart tailored out a list firstly to make sure the specific courses and sequence for each different post."

> The training director of Delphi-China also noted: "The best sequence for learning complex procedural knowledge is listen, look, and do. By 'listen', I mean taking classes. By 'look' I mean visit the foreign partner's working environment and look at how they conduct their daily tasks. By 'do', I mean we should work on some projects to apply what we have learned and find out what we still need to learn. Without listening to instructions of some basic principles in the classroom setting, visit or training overseas would not be as fruitful."

We conclude this section with the following proposition.

> **Proposition 3a.** Individual teaching-individual learning transfers collective knowledge poorly, but can lay a foundation for more complex teaching-learning combinations by transferring individual and codified knowledge.

Group teaching-group learning

The polar opposite of individual teaching-individual learning is group teaching-group learning, in which a group of teachers from the source community work together to demonstrate their common and inter-personal knowledge, while the members of the recipient community share, integrate, and synthesize their learning among themselves. Among the firms we studied, the field data identified two types of overlap between group teaching and group learning.

The first type is the group teaching-group learning that happens at the source community's location. Shanghai –Volkswagen's overseas training program provides a good example. The goal of this project was to develop state-of-the-art R&D capabilities that span all stages and aspects of the vehicle development process. The program involved a team of forty-one managers and engineers, selected by Shanghai-Volkswagen's human resource department. They were located in Volkswagen's vehicle development department to receive training from a team of Volkswagen personnel. As part of the training, the teachers involved them in R&D projects including development of complete vehicles, styling, chassis, engine, and body, as well as computer-related projects. Many of these capabilities required for these projects involved extensive tacit and group-embedded information, making them prime examples of collective knowledge. This on-the-job training in Germany lasted for one year. Then the trainees returned to Shanghai-Volkswagen and worked on local projects for a year. After that, they returned to Volkswagen in Germany to finish the last half year of the three-year training program, again working with teams of Volkswagen teachers. In total, the program cost 1.8 million German Marks (about 1 million euros).

A Chinese participant of this program described this type of group teaching-group learning using a metaphor of "the coupling of two pyramids", saying that:

> "Suppose that the R&D team of Volkswagen is like a pyramid, each building block representing a particular function and each layer of blocks representing a particular managerial level, we [the two teams of trainees] have trainees from each building block at each layer work in the corresponding block and layer of Volkswagen during our overseas training. It is as if our pyramid is coupled with theirs."

Among the firms we studied, Shanghai-Volkswagen adopted a group teaching-group learning strategy most extensively as their primary vehicle for transferring R&D capabilities.

> The Chinese R&D manager said: "Now as we looked back, sending a big R&D team to get on-the-job training in Germany is definitely worthwhile. I cannot imagine having a local

> R&D force that can carry out most of work for modifying Santana and Passat in a short time frame without this type of training."

The second type of group teaching-group learning happens at the site of the recipient community. Examples arose in two representative cases – PATAC and Delphi-Parker. In PATAC's case, teams of foreign managers went to the JV in China to manage all major functional areas. In turn, the Chinese employees worked as a community of recipients, learning and integrating the knowledge they gained from working with the foreign managers. Delphi-Parker's JV in Shanghai, a producer of electric harness, adopted an all-American managerial team at the initial stage of the JV. Every functional unit had an American manager as head, who was also responsible for mentoring his/her Chinese successor. In about six months, half of the American managers completed their jobs and transferred their leadership to their Chinese successors. At the time of the interviews, Chinese nationals filled almost all mid- and low-level managerial jobs.

A Chinese manager of this JV viewed this arrangement as the fastest way of transferring managerial capabilities:

> "Bringing the team of American managers here allows for effective transformation of our ways of management. This approach is similar to sending the Chinese managers for overseas on-the-job training, and is more effective than sending individual American managers to work here in a separated way."

Clearly, transferring capabilities is a highly complex process when the content of collective knowledge is high. Simultaneous application of group teaching and group learning facilitates transfer of collective knowledge. The following proposition is consistent with our initial orienting argument.

> **Proposition 3b**. Among four teaching-learning configurations, group teaching-group learning is the most effective transfer strategy for transferring collective knowledge.

Group teaching-individual learning

Group teaching-individual learning arose in two ways in the cases we studied. The first type involves sending individual members of the recipient community to the source community for on-the-job training without individual students exchanging knowledge or integrating during the training period. Most overseas on-the-job trainings in our study except the 41-person project of Shanghai-Volkswagen used this approach. The second type involves sending individual members of the recipient community to the source community for short-term visits. Typically, with this type of training, there was not enough time for the knowledge recipients to exchange and integrate what they have learned during visit, even though individual knowledge recipients obtained some degree of collective knowledge from the source community.

Respondents commented on the necessity of on-the-job training and on-site visits, but also mentioned that such training without knowledge integration within the recipient community is not enough to cultivate their own capabilities. In some cases, though, group teaching-individual learning led in sequence to individual teaching-group learning, as we discuss in the next section.

Delphi-China's training director talked about a training project for acquiring lean manufacturing capabilities.

> "To help new joint ventures to acquire lean manufacturing capabilities, we first gave trainees an introductory class, and then sent them to a model plant for a 4-day on-site visit, during which the instructor will show and teach them every step of the lean manufacturing process and solutions to all possible problems. But this is only the beginning. The trainees went back to their own location and tried to use what they have learned to improve the productivity of their own manufacturing process with the help one or two facilitators. This is the major part of the training."

The discussions led to the following proposition.

> **Proposition 3c.** Group teaching-individual learning is superior to individual teaching-individual learning in allowing individual learners to acquire collective knowledge from the source community.

Individual teaching-group learning

All the firms we studied adopted individual teaching-group learning combination by engaging in activities requiring group efforts under the guidance of foreign expatriates, well-trained Chinese managers, or outside consultants/trainers. Some firms used individual teaching-group learning as the sole method, others used it in combination with group teaching-individual learning, or group teaching-group learning.

As an example of the first case, one of the firms we studied in the first stage of this research was an old state-owned automotive supplier. It had invested 2 million RMB over the past two years to hire an internationally renowned consulting firm to help them to transform its existing R&D department into a modern R&D organization.

> The R&D department head noted: "We were very optimistic about what the consulting firm can do for us at the beginning. Our goal was to acquire advanced R&D procedures and develop a modern R&D organization. Now, I have to admit that the return on our investment [in hiring the consulting firm] is not satisfactory. A few consultants cannot handle such a complex task. We are looking into the possibility of establishing a joint venture with a good foreign company, which would allow us to learn from them."

Most firms in our study used individual teaching-group learning as a sequenced continuation of group teaching-group learning or group teaching-individual learning. For example, PATAC undertook the individual teaching-group learning stage after the group teaching of its foreign partner tapered off. Its independent design of a new passenger car, the Qilin model, demonstrated the full range of its design and testing capabilities. The Qilin project helped bring the skills that individual engineers had learned from their foreign partner into the perspective of designing a new car for the Chinese market under local conditions.

Group teaching-individual learning followed by individual teaching-group learning is in fact a sequential version of group teaching-group learning. Instead of having concurrent group teaching and learning, group teaching-individual learning followed by individual teaching-group learning implies that individual knowledge recipients first receive group teaching in a relatively independent manner, and then gradually integrate and synthesize individual learning and re-embed it into the recipient community through group projects. Compared with concurrent group-group education, a sequential approach takes longer to achieve collective knowledge transfer. Moreover, since not all knowledge recipients receive training at the same time in a sequenced approach, the trainees who received training earlier will encounter more problems in attempting to diffuse their knowledge to the rest of the community who have not received such training. Therefore, the sequence is less effective than group teaching-group learning.

According to the respondents, though, the advantages of group teaching-group learning over the sequenced approach must be balanced against the cost of transfer. Sending a sizable group of a local work force to another location for training as a team not only incurs training and travel related costs, but also the loss of local productivity.

> As a Chinese manager from PATAC explained: "We know that it would be ideal to get all of our engineers trained at the same time, but we cannot afford it. We have to take a second best option, which is to take a more incremental and long-term approach in training our local employees."

Group teaching-group learning is the most costly combination; it requires high financial and human resource commitments from both communities. Group teaching-individual learning followed by individual teaching-group learning may be a poor firm's version of group teaching-group learning. However, the sequential approach is more effective than either strategy alone. We conclude this section with the following proposition.

> **Proposition 3d.** Compared to group teaching-group learning, the sequence of group teaching-individual learning followed by individual teaching-group learning is a less costly but lengthier and less effective process of transferring collective knowledge.

Overall assessment of group-group education impact on R&D capability levels

We will also attempt to summarize how the firms' collective knowledge transfer strategies affected the overall success of their efforts to develop local R&D capabilities. This is a subjective exercise. As we noted earlier, all four firms used multiple forms of teaching and learning strategies in their knowledge transfer efforts. Moreover, the development of the local partners' R&D capabilities has involved a series of inter-related multi-year activities, rather than distinct projects. As a result, it is impossible to identify the specific impact of different strategies.

Therefore, our primary assessment of transferring collective knowledge derives from the respondents' experience, in which they discussed which elements of their education strategies had helped most in transferring R&D capabilities with high degrees of collective knowledge. The discussions produced a strong consensus, which led to the propositions in this paper.

Nonetheless, it is possible to rank order the extent to which the four alliances used group teaching-group learning knowledge transfer, on the one hand, and their success in developing local R&D capabilities, on the other. As Table 2a notes, Shanghai Volkswagen use group-group education most extensively, followed by PATAC and Delphi-China with roughly similar usage. Beijing Jeep had relatively little use of group-group methods, either concurrently or sequentially.

We asked two industry analysts in China (one is a senior professor specializing in the automotive sector and the other is a manager of an auto industry research center) to assess the status of the firms' local R&D capabilities in mid 2003. According to the analysts, all four local partners increased their local R&D capabilities during the life of the alliances. In turn, the rank order of R&D capability levels that the analysts suggested closely aligns with the use of group-group knowledge transfer. Shanghai Volkswagen has developed the most extensive local vehicle engineering capability; the company is also the market sales leader, with 2001 annual sales of $4.7 billion (Table 2a). PATAC and Delphi-China also have developed substantial local R&D capability, especially in the area of localization design and component engineering, which they use to supply design services and components to Shanghai GM (Shanghai GM had $1.5 billion sales in 2001, about one-third the level of Shanghai Volkswagen). Beijing Jeep, although an early entrant to China, has reached a more restricted level of local R&D capability and has achieved much less local sales success (about $94 million in 2001).

Clearly, attempting to link education strategies with the firms' overall R&D capability development involves many contingencies. Perhaps most notably, investment and time effects arise. As Table 2a shows, Shanghai Volkswagen has created a larger local technical staff than the other firms and invests substantially more in local R&D activities. Shanghai Volkswagen also entered China much earlier than PATAC and Delphi-China. Nonetheless, the willingness to undertake expensive group-group education activities is part of the investment level. Moreover, PATAC and Delphi China have been able to develop local R&D capabilities much more quickly than Beijing Jeep, which entered more than a decade before them. We believe that the use of group-based education has had at least a partial causal impact on the successful transfer of collective R&D knowledge.

DISCUSSION

Traditionally, western epistemology has focused on individual-level knowing entities and learning practices (Cook et al., 1999). It is only recently that scholars have begun to attend to the idea of collective knowledge and group-level learning (Tiemessen et al., 1997). This study focuses on the inter-communal transfer of collective knowledge. We examine the issues of group learning and group teaching. The notion of group teaching, in particular, is largely missing in the management literature and presents a challenge to assumptions that teaching is primarily an individual-based practice.

The cases indicated that group teaching means requires more than simply having a team of teachers. The discussions led us to define group teaching as a process in which multiple teachers work together to teach trainees in the source community's working environment.

The cases identified several dimensions in which group teaching is superior to individual teaching in transferring collective knowledge, which propositions 1a and 1b highlight. When transferring complex capabilities such as R&D capabilities, in which collective knowledge is common, group teaching allows members of the recipient community to understand the shared mindset of the source community, as well as relevant organizing principles and organizational structures. Group teaching also provides members of the recipient community opportunities to observe and learn how members of the source community carry out uncodified within-function and cross-function routines. Moreover, group teaching helps the members of the recipient community to identify which parts of the collective knowledge are idiosyncratic to the source community's context before they attempted to transfer that knowledge back to the recipient community. In addition, group teaching fosters inter-communal bridge networks, which provide direct communication channels between members of the two communities and allow the knowledge recipients to have extended exposure of group teaching even when they are physically apart from the source community.

At the same time, the respondents also noted that students must have sufficient language and technical communication ability to interact with the teachers in the classroom and in the working environment. A Chinese manager from Delphi-China who went through on-the-job training in the U.S. had the following observation.

> "Some Chinese engineers did not learn much during the overseas on-the-job training because of their language problems or lack of inter-cultural communication skills. Whereas others learned a lot by asking questions of their American colleagues and observing how they handle various issues…Although I came to the US to learn manufacturing technology, I was driven by curiosity and the demands of work to ask many non-manufacturing questions. And I was surprised by their willingness and capabilities for answering my questions. I also learned a great deal about how people from different areas interact and coordinate with each other by observing the project team meetings. I would not have learned these important things, had I not worked in the US with so many American colleagues."

In turn, the interviews highlighted two aspects of group learning, beyond gaining collective exposure to same problems and solutions. These include the need for contemporaneous learning and intense interaction among learners. Thus, we now define group learning as a process in which trainees learn together as an interactive group.

The cases identified several dimensions on which group learning offers benefits for transferring collective knowledge (proposition 2). Group learning helps members of the recipient community to develop a shared mindset and value system. Group learning helps recipients understand division of labor and coordination practices. Group learning helps recipients understand who does what within a community, as well as develop a collective memory. Group learning helps recipients develop coordination routines. Group learning also helps re-embed individual learning with recipients' local context.

Combining teaching and learning strategies as two aspects of one knowledge transfer mode, we developed a typology of teaching-learning configurations. Based on the discussions concerning teaching and learning strategies, we find that a group teaching-group learning combination facilitates effective transfer of collective knowledge (propositions 3a to 3d).

One implication of this conclusion might be that firms that need to transfer capabilities with high collective knowledge content should rely only on group teaching-group learning education strategies. However, each firm in our study adopted all four teaching-learning combinations in attempting to transfer collective knowledge.

Our observations yielded several insights regarding these seemingly-wrong choices. First, group teaching-group learning may be the most effective and fastest method (proposition 3b), but it is also the most costly combination. Second, group teaching-individual learning followed by individual teaching-group learning is a sequential and often a lower-cost version of group teaching-group learning (proposition 3d). Third, individual teaching-individual learning before other modes can be helpful as a priming mechanism (proposition 3a).

How do group teaching and group learning affect the transfer of individual-level knowledge or codified group-level knowledge? Group teaching and group learning involve more interpersonal interactions among a group of people and therefore incur greater cost than individual teaching and individual learning. Using group teaching to teach individual skills that can be taught by individual teachers will not only incur unnecessary higher cost, but may also cause loss of focus and information overload to the knowledge recipients. For instance, few firms have sent computer-aided design (CAD) operators to overseas on-the-job training, because their jobs are focused and individually-based.

Two Delphi-China joint ventures provide contrasting examples of different yet successful knowledge transfer strategies. One venture in China produces electric wiring harnesses, which have low group-embeddness and tacitness because the products are simple, using single-function design and manufacturing processes. Individual teachers from Delphi train Chinese engineers for the wiring harness venture entirely in China. In contrast, another joint venture of Delphi-China produces steering systems, which are more technically sophisticated and demand cross-functional coordination in their complex development processes. In this case, the R&D capabilities involve high group-embeddedness. Delphi undertook group teaching in the steering system case, sending Chinese employees to Delphi's U.S. home base for on-the-job training with multiple teachers.

In general, though, when the content of collective knowledge is high, firms benefit if they include group teaching and group learning in their teaching-learning configurations. The collective knowledge tends to transfer more accurately and quickly when compared to other education configurations.

We found three main causes among firms that did not follow this basic principle. First, some poor choices arise from time pressure.

Second, firms sometimes lack resources needed for time-consuming and expensive group teaching and group learning. Perhaps most often, the missing resources are human resources, in which the firms lack teachers and trainees with the skills needed for group teaching and group learning succeed.

Third, poor choices also arise because of limited understanding of the critical role that collective knowledge plays in successful transfer of many capabilities. Firms may under-estimate the need for group teaching and/or group learning in transferring capabilities between firms. Firms often over-emphasize the "technical" aspects of transferring capabilities, emphasizing teaching how to use specific equipment or conduct specific tasks. While this approach is appropriate for capabilities that rely on explicit information and individual skills, much of the activity of modern business relies on tacit understandings and group-wide routines. Although many managers may recognize this issue as a general factor, time pressure and lack of analysis often lead them to ignore collective knowledge in detailed practice, ultimately resulting in failed transfer. By contrast, technology transfer is most likely to succeed when firms incorporate an understanding of collective knowledge into their detailed activities.

The empirical setting of this study has significance in its own right. The auto industry is a pillar industry of China and the Chinese auto market is one of the fastest growing markets in the world. With China's WTO entry, one of the urgent items for multinational firms' operations in China is to develop local R&D capabilities in order to compete in a growing local market. Previous empirical studies have shown that personnel from less developed countries need not only specific knowledge of various stages and aspects of project preparation, implementation, and operation, but also need higher level understanding of why things are managed in certain ways (Marton, 1986). One special character of transferring R&D capabilities in China's context is that historical mindsets and routines that developed around central-planned economy over many decades often burden recipient communities. Many respondents mentioned that changing such organizational mindsets and cultures is more important, and yet more difficult, than learning technical skills. Group teaching-group learning is particularly helpful for recipient communities with heavy historical baggage, because group teaching-group learning can reduce the difficulty of knowledge diffusion due to group inertia.

This study also provides practitioners with a rich description of capability transfer practices and a framework that can help them to formulate their own strategies for transferring capabilities. It also helps explain the success or failure of past capability transfers, and provides guidelines for practitioners to formulate strategies to transfer the key element of capabilities – collective knowledge. Sending expatriates, developing training classes, or offering overseas training typically does not produce effective knowledge transfer of collective knowledge. Commitment without appropriate mechanisms is often a bad investment.

The study indicates two types of mistakes due to mismatch between knowledge type and teaching-learning modes. The first type is overkill, which is to transfer individual-level or codified knowledge with group teaching or group learning strategies. This will not only incur unnecessary high transfer cost, but may also cause loss of focus or information overflow. The second type of mistake is under-use, in which firms use individual teaching or learning strategies to attempt to transfer complex group-wide capabilities.

The interviews suggest that under-use was more common than over-kill. Firms often did not adopt group teaching when designing training programs involving extensive sets of collective knowledge, instead relying on single trainers in attempts to teach organization-embedded capabilities. In parallel, many firms did not recognize the need for group learning, instead relying on short-term training programs, in which trainees did not have opportunity to share and integrate their learning.

Thus, the study offers several practical implications. First, combining group teaching and group learning provides a superior mechanism for transferring capabilities with high collective knowledge content. Second, using individual teaching-individual learning to prime group teaching-group learning or group teaching-individual learning may be effective. Third, if firms cannot afford group teaching-group learning, due to the lack of financial or human resources, a sequence of individual teaching-individual learning, group teaching-individual learning, and then individual teaching-group learning sequence offers a slower but potentially viable substitute.

Clearly, there is room for future work. Future research can sharpen measures of transfer cost, group teaching and learning, and the level of group-embeddedness or tacitness of knowledge. Research can investigate situations in which tacitness and group-embeddedness change after crossing organizational boundaries. It would be valuable to examine how variation in socio-cultural distance might moderate the teaching and learning strategies. It would be helpful to examine the joint effects of different configurations of teaching strategies and learning strategies. It would be valuable to examine how differences in proprietary protection and expansion goals influence source firm's incentives to transfer capabilities. It would be useful to examine recipient variation in absorptive capacity and incentives. In addition, it would be useful to extend the study to include issues related to opportunism and property rights. Finally, research with larger samples and quantifiable data would refine the conclusions. We believe that this study provides a useful basis for undertaking such extensions.

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Table 1. Configurations Of Teaching And Learning Strategies

		Teaching Strategies	
		Group Teaching	***Individual*** *Teaching*
Learning Strategies	***Group Learning***	A group of teachers from the source community work together to demonstrate their common and inter-personal knowledge, while the members of the recipient community share, integrate, and synthesize their learning among themselves	Individual teachers from the source community independently teach a group of members from the recipient community. The members of the recipient community share, integrate, and synthesize their learning among themselves.
	Individual Learning	A group of teachers from the source community work together to demonstrate their shared belief and coordination routines to individual members from the recipient community. The members of the recipient community do not engage in significant knowledge sharing, integration, and synthesis during the teaching process.	Individual teacher(s) from the source community teach individual members from the recipient community. The teachers work independently in their teaching activities. The members of the recipient community do not engage in significant knowledge sharing, integration and synthesis while receiving training.

Table 2a. Companies Studied

	Shanghai-Volkswagen (SVW)	Pan Asia Technical Automotive Center (PATAC)	Delphi-China	Beijing-Jeep Co. (BJC)
Chinese Partner	SAIC, Bank of China, and CAIC	SAIC	9 different Chinese auto suppliers	Beijing Auto Work (BAW)
Foreign Firm	VW AG, Germany	General Motors, USA	Delphi Auto Systems, US	Daimler-Chrysler (D-C), Germany
Initial Registered Capital	19 million US$	50 million US$	N/A	147 million US$
Total Initial Investment	$119 million	$50 million	Total investment by Delphi: over $400 million by 2000.	$411 million
Equity Share	SAIC: 25% Bank of China: 15% CAIC: 10% VW AG: 50%	SAIC: 50% GM: 50%	Delphi: Varies from 40% to 100%. Delphi has 9 joint ventures and 3 wholly owned operations in China	BAW: 58% D-C: 42%
Year Established	1985	1997	Varies from 1995 to 1998	1983
JV Contract	25 years	30 years	Varies from 30 to 50 years	20 years
Location	Shanghai	Shanghai	Various locations in China	Beijing
Main Product	VW brand compact vehicles and auto components.	Automotive R&D services, including localization of foreign vehicle design, market research, design, & styling.	Automotive components, such as steering systems & electric harnesses.	Cherokee SUV & Chinese brand SUV
Capacity	300,000 vehicles	Does R&D for Shanghai GM	Sells to Shanghai GM.	80,000 vehicles
Automotive Sales	2001: $4.7 billion	Shanghai GM, 2001: $1.5 billion	2000: $400 million	2001: $94 million
R&D Capability	SVW launched a 10-year plan to develop concurrent and multiple-generation local R&D capabilities. It has invested 0.8 billion RMB ($100 million) to add prototyping and testing facilities to its technical center.	PATAC offers a comprehensive range of design, analysis, and testing services, including computer-aided five-axis exterior model making, simulated road testing, and engine emission testing.	The main task of the Delphi technical center in China is to localize the design and production of auto components designed in the U.S.	BJC has a local R&D division that handles the R&D process from concept design to prototyping and testing based on modern R&D procedures, concurrent engineering and platform team approach. Most managers are trained overseas.
R&D Activities	Localized the design of the Passat and Santana compact cars. The projects required major exterior and body extension, involving full-scale product development. Chinese engineers identified styling and performance requirements. Most design and testing/validation took place in Germany. Chinese engineers undertook modifications such as retuning engines for high altitude applications.	Designed the Qilin compact car model in 1999 and localized Opel Corsa and GM Venture in 2000. Jointly designed a van with Porsche. The R&D localization involves tasks such as redesigning heating and air conditioning systems, modifying engine control system to fit the local road and fuel conditions, and meeting local regulations.	Localized component designs, manufacturing processes, material sourcing, and testing methods for products such as half shafts, steering columns, and brakes for local auto OEMs including Shanghai-GM, Shanghai-Volkswagen, and Guangzhou-Honda.	Since 1985, BJC has competed concept design of three SUV platforms and modified the Jeep Cherokee to multiple localized versions. In the concept design for BJ2 platform, BJC went through the R&D process from market research to prototype testing indigenously.

Technical Staff (Expense) *	2001: 950 staff ($28 million)	2001: 160 engineers, designers, scientists, & technicians.	2001: 30 local engineers	2001: 370 staff ($1.3 million)
Main Knowledge Transfer Methods	1. Sending 41 engineers for overseas in-class and on-the-job training for 3 years. 2. Developing a training center in Shanghai to offer classes to local engineers and managers in Chinese. 3. Working on real R&D projects under the guidance of foreign experts and experienced Chinese managers. ➢ Most extensive use of group teaching-group learning.	1. Having foreign expatriates take management positions for each functional area. 2. Sending individual & groups of Chinese engineers for US in-class and on-the-job training. 3. In-class training. 4. Working on R&D projects under the guidance of foreign experts and experienced Chinese managers. ➢ Substantial use of group teaching-group learning.	1. Sending individual & groups of Chinese engineers for US in-class and on-the-job training. 2. Developing a training center in Beijing to offer classes to local engineers in Chinese. 3. Working on engineering projects under the supervision of experienced Chinese managers and foreign expats. ➢ Substantial use of group teaching-group learning.	1. Sending Chinese engineers for overseas in-class and on-the-job training, as individuals or in small groups. 2. Working on design projects jointly with foreign design firms. 3. Working on design projects under the supervision of experienced Chinese managers ➢ Least use of group teaching-group learning.
Success in developing local R&D capabilities	Strong local vehicle engineering capability.	Strong localization design capability.	Strong local component engineering capability.	Success in developing more focused development capabilities.

Sources: In addition to interviews, we obtained data from annual reports, trade press publications, the "Summary & Guide of Foreign Enterprises in China Automotive Industry" published in 1998, and from the China Automotive Technology Research Center in Tienjin.
* The technical figures are only roughly comparable across firms, because the companies use somewhat different criteria to report investment ("Annual expenses on science, technology, and R&D activities") and staffing ("Engineering and technical employees") levels.

Table 2b. Respondent Backgrounds

Company / **Position**	Shanghai-Volkswagen	PATAC	Delphi-China	Beijing Jeep	**Total**
HR-Training	2	1	3		6
Project Engineer	1	1	5		7
Project Manager	1	1	2	1	5
R&D Manager	1	1	1	1	4
Top Management		1	1	2	4
Total	5	5	12	4	26

Table 3. Examples of the Advantages of Group Teaching for Transferring Collective Knowledge

Group Teaching Advantages	Example Quotes
1. Members of the recipient community can understand the shared mindset of the source community.	• "Overseas training allowed me to interact with my American counterparts, gained deeper understanding of the national, company and departmental cultures. It teaches how to better communicate with my American colleagues." (A project engineer from Delphi-China) • "The main knowledge we learned from overseas training is not individual skills such as CAD usage, but the mindset that guides the product development process."(The director of Beijing Jeep's R&D department)
2. Members of the recipient community can observe organizing principles and organizational structures that the source community uses to perform certain tasks.	• "Coming to the US to learn is a must. Otherwise we will never truly understand the process of product development, and how to set up the product development organization." (A project manager of Delphi-China) • "Training overseas is absolutely necessary for Chinese employees. Had we not gone to US for on-the-job training, we would never get to know organizational structures and the way things work in Delphi. Training overseas is not only important for managers but also for mid-level and lower-level engineers." (A project engineer from Delphi-China)
3. Members of the recipient community can observe how members of the source community carry out un-codified routines within functional areas.	• "The most important thing I learned in the US that I cannot learn from any other sources is the detailed way of solving various problems." (A project engineer from Delphi-China) • "At the beginning, we did not know a lot about VW AG's R&D process, we encountered a lot of difficulties in the learning process. What were written in the training materials and operation manuals are not detailed enough to cover all possible situations in the design process. And even if the written procedures cover everything, each German engineer seems to have his own personal way in interpreting these procedures. What we really need to learn is not the procedures, but the way of interpreting and applying them. This type of knowledge would be impossible to obtain had we not come to VW AG and work with German engineers on a daily basis." (A Chinese manager in the product development area of Shanghai-Volkswagen who participated the training program) • "If we did not send Chinese engineers for overseas training, we may learn from US expatriates here in PATAC, but the learning would be much limited because individual teaching cannot cover various contingencies and situations." (A Chinese project manager at PATAC)

4. Members of the recipient community can observe how members of the source community carry out un-codified routines across functional areas.	• "The framework of R&D routines that we have learned in Saginaw cannot be learned through reading the product development procedure. Only after we completed the overseas training, can we start to understand the procedure." (A project engineer from Delphi-China) • "Without overseas on-the-job training, it is impossible to understand the concrete details of how to coordinate across many functional areas in the product development process, even with the full understanding of the written procedure. Of course, we can develop our own product design procedure from the scratch, but it will take a very long time. It's important to learn our American partner's procedure and work with American colleagues to fully understand it." (The R&D director of Beijing Jeep) • "Through doing many R&D projects, we have grasped the essence of Chrysler's Product Approval Process (PAP), which clearly specifies all the jobs, coordination among different functional areas, and usage of various resources. Based on PAP, we gradually comes up with a more effective R&D procedure, which better suits Beijing Jeep's operation. The development of BJ2 was greatly benefited from utilization of this modified R&D procedure." (The R&D director of Beijing Jeep) • "It is very useful to receive in-class training to understand the basics of product development process. But that is far from enough. We learned much more about the product development procedure when we worked on some joint projects with American colleagues in Delphi-Saginaw's engineering department. For instance, I learned how to coordinate with testing and manufacturing engineers through solving real problems." (A project manager from Delphi-China)
5. Members of the recipient community can identify which parts of the collective knowledge are idiosyncratic to the source community's context before they attempted to transfer that knowledge back to the recipient community.	• "A lot of product development practices are not based on pure science. There are a lot of contextual and situational elements that are idiosyncratic to our foreign partner and are not suitable to our environment back in China. For example, some steps of a product development procedure were developed in the U.S. based on the capacity limits of a particular plant. Through interacting with many American engineers who understand the original intention of this procedure, we were able to identify these steps and remove them before the procedure was transferred to China." (A Chinese project manager from Delphi-China)
6. Members of the recipient community can develop a trust-based network with multiple members of the source community and a knowledge of who does what the best among them (bridge network).	• "In order to continuously acquire R&D knowledge, knowing who knows what and who has the authority to answer various questions is very important. If everyone from the team of 41 persons knows 10 different VW experts, we would develop a network involving about 400 German experts at the end of the 3-year training. As the training came to the end and most trainees returned to Shanghai-VW, the benefit of this network started to show. Trainees, working in relevant positions now in Shanghai-VW, communicate frequently through this network via e-mail and telephone with their German colleagues." (A Chinese manager of Shanghai-Volkswagen) • "Human beings are emotional creatures. Knowing each other through face-to-face contact, even in a very brief manner, can qualitatively change the nature of information exchange. Overseas training only helped us to start. In our everyday work here, new products, new customers and new processes keep coming up. We have to keep a close contact with American engineers to operate properly. If I don't have this network, my work would be much tougher." (A Chinese engineer of Delphi-China) • "Overseas training gives us a windfall – a network connecting us and foreign experts. You just cannot imagine how much easier it is for us to get information we need from American personnel when we have personal relationship with them. It's interesting that in the US, people also go about their work based on *guanxi*. A good *guanxi* between a Chinese and an American personnel means a informal and high quality information channel between them" (A Chinese manager at PATAC)

Table 4. Examples of the Advantages of Group Learning for Transferring Collective Knowledge

Group Learning Advantages	Example Quotes
1. Members of the recipient community develop a shared mindset and value system.	• "Over the past five years, through several rounds of vehicle development projects, we have developed a culture that is neither Chinese nor American, but PATAC-specific." (The Chinese top manager of PATAC) • "If the trainees went overseas at the same time but participated in different R&D projects, the coordination and development of a shared understanding among the trainees was not as strong as when they went for same project." (A project engineer from Delphi-China)
2. Members of the recipient community understand the division of labor, coordination, and alignment of individual tasks.	• "We share knowledge learned and help each other to understand things from different perspectives. We discuss especially how German engineers interpret situations and solve problems, in other words, the things that are not written in manuals. The discussion among us really helped me to understand my part of the business and what my Chinese colleagues are doing in their parts of business." (A project engineer from Shanghai-Volkswagen).
3. Members of the recipient community understand who does what within the community	• "The classes we took cannot teach us whom a test engineer should talk to when he finds out a design defect in his test. We need projects to work on. Only when there is a project, can we form a team. And only when the team work on this project day after day, month after month, can they understand whom they should talk to when a particular issue arises." (A project engineer of Beijing Jeep)
4. Members of the recipient community develop coordination routines, thus creating a collective memory.	• "We have all received in-class and overseas training on product development process. However, it was only after we worked together as team on several projects, that we really started to learn how to solve problems, make compromises and share resources among many aspects of design work at various stages." (The R&D manager of Shanghai-Volkswagen) • "At the very beginning of BJ2 development project, we formed a cross-function management team, which involves personnel from product design, manufacturing, purchasing, finance, and marketing departments. After 3 years of practices on this project (BJ2), we have developed a matured and scientific product development procedure. Each functional department has gained better understanding of concurrent engineering, and can coordinate with other departments more effectively." (A project engineer of Beijing Jeep)
5. Members of the recipient community re-embed individual learning with their local context.	• "The technological levels of our Chinese suppliers are very different from those of the American suppliers. So, we have to make adjustment to some procedures to make things work in China." (A project manager of Delphi-China) • "The testing of R1 prototype of BJ2 revealed about 500 design defects, each of which needs to be dealt with by multiple departments. To solve this complex network of issues, we rely on the guidance of a relevant procedure developed by Chrysler. We modified this procedure to better suit our condition, and then formalized it in written form to guide future projects." (A project engineer of Beijing Jeep)