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

By: Zheng Zhao, Jaideep Anand, and Will Mitchell

William Davidson Working Paper Number 420
December 2001

Transferring Collective Knowledge: Collective and Fragmented 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

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
The Fuqua School of Business, Duke University
Box 91020, Durham, NC 27708-0120
Email: **Will.Mitchell@duke.edu**
Phone: 919.660.7994, Fax: 919.681.6244

December 7, 2001

Acknowledgements: We greatly appreciate the funding support of the William Davidson Institute of the University of Michigan Business School. We thank all respondents in China and the U.S. for their assistance and insights.

William Davidson Institute Working Paper 420

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

Abstract

Collective knowledge, consisting of tacit group-embedded knowledge, is a key element of organizational capabilities. This study undertakes a multiple-case study of the transfer of collective knowledge, guided by a set of tentative constructs and propositions derived from organizational learning theory. By focusing on the group-embeddedness dimension of collective knowledge, we direct our attention to the source and recipient communities. We identify two sets of strategic choices concerning the transfer of collective knowledge: *collective vs. fragmented teaching*, and *collective vs. fragmented learning*. The empirical context of this study is international R&D capability transfer in the Chinese auto industry. From the case evidence, we find the expected benefits of collective teaching and collective learning, and also discover additional benefits of these two strategies, including the creation of a bridge network communication infrastructure. The study disclosed other conditions underlying the choice of strategies of transferring collective knowledge, including transfer effort and the level of group-embeddedness of the knowledge to be taught or re-embedded. The paper provides a group-level perspective in understanding organizational capabilities, as well as a set of refined constructs and propositions concerning strategic choices of transferring collective knowledge. The study also provides a rich description of the best practices and lessons learned in transferring organizational capabilities.

Keywords: knowlege transfer, collective knowledge, organizational capabilities, R&D capabilities, organizational learning, network, China

William Davidson Institute Working Paper 420

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

Organizational knowledge and knowledge transfer have emerged as central themes of managerial theories and practices. A large volume of theoretical and empirical work exists in both areas (Argote & Ingram, 2000a; Argyris & Schon, 1978; Brown & Duguid, 1998; Conner & Prahalad, 1996; Kogut & Zander, 1992; Levitt & March, 1988; Nelson & Winter, 1982; Nonaka & Takeuchi, 1995; Polanyi, 1962). Notwithstanding significant progress in our understanding of organizational knowledge and knowledge transfer, many under-explored areas remain. One area that is especially in need of timely research is the transfer of collective knowledge (i.e. tacit group-embedded knowledge), which is a key component of organizational capabilities and is highly difficult to transfer (Cook & Brown, 1999; Kogut et al., 1992; Spender, 1996).

In recent decades, both inter- and intra-firm transfer of various kinds of collective knowledge have been practiced increasingly in the field and have caught the attention of growing numbers of researchers. Transfer activities that have been studied include intra-organizational spread of best practices (Gupta & Govindarajan, 2000; Kostova, 1998; Szulanski, 1996), cross-boarder transfer of R&D management among multinational firms' subsidiaries (Inkpen & Dinur, 1998), and inter-alliance partner transfer of know-how (Brewer & Nollen, 1998; Singh, 1995). Most of these studies focus on the effects of contextual constraints or endowments (such as absorptive capacity, transfer intent, relational capital and country-level factors) on the outcome of the transfer activities. Among the few empirical studies that address the strategic actions for inter-communal transfer of collective knowledge, there is little systematic analysis and theoretical generalization of the empirical findings.

The goal of this study is to advance the inquiry of knowledge transfer by identifying and theorizing the strategic actions of transferring collective knowledge. The research question is "what strategic teaching and learning mechanisms enable effective inter-communal transfer of collective knowledge?" The research approach is a theory-guided exploratory multiple-case study, which starts from epistemological discussions of collective knowledge and requirements for its transfer, and moves on to field investigations to inductively develop a theory of the strategic factors that lead to effective transfer of collective knowledge. This approach allows recombination of insights from both previous theories and empirical findings of this study.

We selected the activities of western multinational enterprises (MNEs) that are transferring R&D managerial practices to their operations in the Chinese auto industry as the empirical setting, for four reasons. First, R&D management in auto industry is highly complex and has a large portion of collective knowledge content. Second, there are growing evidences of transferring R&D capabilities from MNEs to operations in that industry. Third, because the source units are from industrial developed countries and the recipient units are from China, the cultural, technical and managerial differences between the source and recipient organizations are similar across the cases (Beamish, 1993; Child and Yan, 2001), and provide a similar contextual setting for the study. Fourth, evidence from previous fieldwork suggests that the cross-case knowledge transfer choices exhibits sufficient variation to identify useful relationships.

The findings from a theory-building multiple-case study based on field investigations of four exemplar international joint ventures extend the knowledge transfer theories by deriving a set of empirically valid generalizable propositions. The rich and in-depth descriptions of the findings and the general propositions may also provide helpful empirical implications for the practitioners who participate in the transfer of organizational capabilities that have significant collective knowledge content.

THEORETICAL FOUNDATION

Among many dimensions of organizational knowledge, tacit vs. explicit and individual-carried vs. group-embedded are the two most salient dimensions in the management field (Cook et al., 1999; Kogut et al., 1992; Nonaka et al., 1995; Spender, 1996). The type of knowledge that is both tacit and group-embedded is termed as *collective knowledge*[1] by Spender (Spender, 1996), and as *organizational genres* by Cook and Brown (Cook et al., 1999). Collective knowledge reveals itself in many forms, such as norms, values and mental maps (Hedberg, 1981; Levitt et al., 1988), uncodified routines, and organizing principles of interactions (Argote et al., 2000a; Kogut et al., 1992; Nelson et al., 1982), uncodified architectural knowledge (Henderson & Clark, 1990), and transactive memory or collective interpretive scheme (Daft & Weick, 1984; Fiol & Lyles, 1985; Levitt et al., 1988; Wegner, 1987). Among the four knowledge combinations that the tacit vs. explicit and individual-carried vs. group-embedded dimensions categorize, collective knowledge (i.e., the tacit and group-embedded combination) is the hardest to transfer, due to its tacit and group-embedded nature, and provides a primary source of sustainable competitive advantage and high value-added "Penrose rents" (Amit & Schoemaker, 1993;

Dierickx et al., 1989; Penrose, 1959; Spender, 1996). Firm capabilities, such as R&D capabilities, are a mixture of all four knowledge combinations. However, it is the collective knowledge content that gives the most strategic value to the capability.

In this study we focus on the collective knowledge within organizational capabilities and its transfer across communal boundaries. To do so, we consider both the tacitness and group-embeddedness characteristics of collective knowledge.

Considering the tacit aspect of collective knowledge, it has long been established that stable and close contacts must be developed between the transferor and the transferee in order to transfer tacit knowledge. This usually calls for the transferor and the transferee to conduct certain shared practices or joint projects, which facilitate close person-to-person contacts and sufficient periods of learning-by-doing (Arrow, 1962; Brown et al., 1998; Levitt et al., 1988; Nonaka et al., 1995; Polanyi, 1962). In the practice of transferring R&D capabilities, both the source and recipient organizations usually engage in joint R&D projects, which serve as platforms for transferring tacit capabilities, which cannot be fully conveyed by verbal or written media (BIC 1992). Nevertheless, learning-by-doing through joint practices is only a necessary condition for transferring collective knowledge, not sufficient, because it alone does not resolve the difficulty of transferring collective knowledge arising from group-embeddedness.

The group-embedded aspect of collective knowledge, unlike the tacit aspect, has not been systematically addressed in the previous theoretical and empirical works of knowledge transfer. Spender & Grant (1996:7) note that “The surge of interest on organizational capabilities and competences has directed attention to organizationally embedded knowledge, but has made only limited progress in understanding its anatomy and creation.” The main task of this study is to address the transfer of collective knowledge with an emphasis on its group-embedded nature.

The key consideration for transferring group-embedded knowledge is that the knowing entity of the group-embedded knowledge is not individuals or the simple sum of the individuals. Instead, it is a group or a community. Collective knowledge, such as routines, involves systems of coordinating relations among members of the knowing community, and is at least partly independent of the individual members who execute them and is capable of surviving considerable turnover in individuals (Levitt et al., 1988; Nelson et al., 1982). “The body of 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” (Cook et al., 1999:386) . The transfer of collective knowledge is in general an inter-communal activity, which involves and goes one level beyond mere interpersonal knowledge transfer (Brown et al., 1998). There are two communities involved in the transfer of collective knowledge: the *source community*, which is the irreducible knowing entity of the targeted collective knowledge, and the *recipient community*, in which the targeted collective knowledge is to be adaptively re-embedded.

Collective Teaching vs. Individual Teaching

Because tacit and group-embedded knowledge resides in collective mental maps, behavioral norms, and tacit interaction routines among members, the knowledge can only reveal itself by being brought to play in specific circumstances, in which the members of the knowing source community interact among each other to carry out certain routines or solve certain problems (Fiol et al., 1985; Levitt et al., 1988; Nelson et al., 1982). Hence, in order for a member of the recipient community to learn this type of knowledge, he or she may need to participate in the ongoing activities of the source community and even become its quasi-member. Observing and participating in the routine work of the source community can allow each learner to not only absorb the knowledge carried by individual teachers, but also knowledge embedded among them. Becoming embedded in the source community can also socialize the learners with the source community's coding scheme, value system, norms, and mental maps, which are important part of source community's collective knowledge and source organization's capabilities (Nonaka et al., 1995). This embedded participation of a knowledge recipient in the source community enables the recipient to be taught by the entire source community. We term this teaching strategy as *collective teaching*.

In contrast to collective teaching, another type of teaching implies that the members of the recipient community do not receive the opportunities of embedded participation in the source community. Instead, members of the recipient community are instructed or supervised by individual expatriates from the source community in a discrete manner. We term this type of teaching as *fragmented teaching*. Fragmented teaching by the members of the source community may not bring the collective knowledge to the members of the recipient community. Teece (1986: 20) notes that "…it will often not suffice to transfer individuals. 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" (Teece, 1986:20). Based on this discussion, we frame the following orienting proposition to guide further field investigations.

Orienting Proposition 1: Collective teaching is more effective than fragmented teaching for inter-communal transfer of collective knowledge.

Collective Learning vs. Fragmented Learning

In the last section, we discussed teaching strategies (i.e., collective and fragmented teaching) that deal with how the source community teaches individual members of the recipient community. In this section, we consider learning strategies, which address how the recipient community can adapt and re-embed the individual learning of its members.

Learning activities in an organization can happen at three different levels: organization, group, and individual (Inkpen, 1997; Tiemessen, Lane, Crossan, & Inkpen, 1997). Group or organizational-level learning implies adapting and embedding individual-level inferences from history into group-level routines, norms, rules, procedures, conventions, frameworks, paradigms, codes, cultures, and technologies, around which organizations construct themselves and through which they operate (Levitt et al., 1988). Moreover, the group-level is situated and distributed (Araujo, 1998; Lave & Wenger, 1991), while much learning takes place in groups (Brown et al., 1998). Researchers often take a rather insular view of learning, however, by focusing on the individual level of learning (Argote, Ingram, Levine, & Moreland, 2000b), while the importance of group perspective in learning is often neglected (Tiemessen et al., 1997:383).

We define *collective learning* as a learning strategy in which members of the recipient community learn interactively as a community, as well as learning individually. In this view, a group-level knowledge base such as routines and transactive memory forms during the learning process. We note that collective learning may occur while the source community engages in either collective teaching or individual teaching. In other words, collective teaching and learning are two orthogonal strategic options concerning the transfer of collective knowledge.

In contrast to collective learning, another learning strategy is for members of the recipient community to be trained in a discrete manner over different time periods and/or in different places. We term this discrete learning strategy as *fragmented learning*. Based on this discussion, we propose the following orienting proposition to guide further field exploration.

Orienting Proposition 2: Collective learning is more effective than fragmented learning for inter-communal transfer of collective knowledge.

METHODS

Research Design

The underlying research design of this study is a multiple-case study for theory-building based on the "blueprints" of *a priori* proposed constructs and tentative propositions, derived from literature review and previous field visits. The strength of using the inductive case method is significant when (1) "how" or "why" questions are posed, (2) causal links are complex, or (3) the main goal of the study is to generate novel theory that is empirically valid and testable (Eisenhardt, 1989). The multiple-case design also permits analytic generalization and replication logic (Yin, 1994). The case study method can be especially revealing for resource-based and 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; Inkpen et al., 1998; Leonard-Barton, 1992; Rouse & Daellenbach, 1999).

In establishing the theoretical function, we identified two sets of strategic options in transferring collective knowledge, "collective teaching" vs. "fragmented teaching" and "collective learning" vs. "fragmented learning". Prior research, however, has not thoroughly operationalized their specific dimensions, empirical implications, and relationships with the effectiveness of capability transfer activities, so that there is an opportunity for inductive development from the case study.

Because R&D capability transfer provides the empirical setting to study the transfer of collective knowledge, we take individual R&D capability transfer practice as the unit of analysis. Although collective knowledge is not the entire composition of R&D capabilities, by probing the interview questions specifically toward the collective content of R&D capabilities, we were able to solicit relevant field data.

Data Collection

Case selection of this study derived from three principles: (1) theoretical sampling, i.e., cases were chosen for replication or extension of the emergent theory, not for statistical randomization purposes (Eisenhardt, 1989), (2) maximization of variance in constructs, and (3) capitalization on personal relationships between the first author and the key respondents from companies studied to ensure interview access and high quality of data (Inkpen, 1997). We use a single industry, the Chinese auto industry (see Appendix I for details), to provide greater control over industry-level factors. Because the constructs are general across industries, we expect generalizability of the final outcomes of this study to go beyond this industry setting.

We conducted data collection in three stages. During the first stage, which took place in the summer of 2000, the first author conducted an initial field study, which involved open-ended interviews with thirty-one respondents from nine companies in the Chinese auto industry. These companies are international joint ventures that had conducted R&D capability transfer. The main purpose of this stage was to understand the context and develop initial framing of constructs and tentative relationships among constructs.

The second stage of the fieldwork, an in-depth case study, took place during the summer of 2001. More focused semi-open questions were administered to twenty-one respondents from four companies. Each of the four companies had conducted multiple R&D capability transfer events and applied all four types of transfer strategies (i.e., collective and fragmented teaching and learning). Among these four companies, two are OEM joint ventures (Shanghai-VW and Beijing Jeep), one is a set of auto component joint ventures (Delphi-China), and the other is an R&D joint venture (PATAC). The cases represent a significant range in group-embeddedness of R&D capabilities to be transferred. The R&D capabilities to be transferred within an OEM joint venture are usually more group-embedded than those to be transferred within a component joint venture. Similarly, the R&D capabilities to be transferred in a component joint venture that produces complex products are more group-embedded than those to be transferred within a component joint venture that makes simple products. The number of cases of R&D capability transfer events among these four companies is sufficient for an in-depth theory-building multiple-case study (Yin, 1994). Table 1 summarizes the companies. Appendix II provides a detailed description of general operations and capability transfer practices of each company.

The third stage of the study involved interview follow-up. We verified the case write-ups with the respondents. We also asked clarification questions by telephone during the fall of 2001.

We used multiple sources of evidence to achieve construct validity. We used multiple data collection methods, including face-to-face interviews, field observations, telephone interviews, and secondary sources of information about the company and the particular R&D related projects of our interest. At each site, multiple respondents ranging from engineers to top managers were interviewed individually to allow multiple perspectives on the same case of R&D capability transfer. The respondents have experiences with multiple R&D capability transfer events and all four knowledge transfer strategies. This is especially valuable because it permits the respondents to give comparisons of various strategies used in transferring R&D capabilities.

All interviewees in the second stage of this study are Chinese recipients of the R&D capability transfer because we believe that, compared with the members of the source community, those from the recipient community better understand the learning needs and learning results. Each interview section lasted from 2 to 5 hours. The conversations of the interview were hand written on site and then transcribed into a more formal format within 24 hours of the interview.

In each interview, we followed the same protocol to ensure reliability (Yin, 1994). The protocol consists of three parts. First, an interview began with the interviewee's personal background and his/her perception of the development and status of R&D capabilities of the company. In the second part, the interviewee was asked to give a detailed chronology of the particular R&D project(s) he/she participated in that involved transferring R&D capabilities from the source community (usually a multinational firm) to the recipient community. Lastly, more specific and probing questions were asked to acquire the interviewee's personal opinions about knowledge strategies with regard to the effectiveness of transferring the collective knowledge content of R&D capabilities. R&D capabilities include (1) hardware/software, such as CAE workstations and design software, (2) individually-carried knowledge/skill, and (3) collective knowledge, such as architectural knowledge, group-embedded R&D procedural knowledge, and product-specific design language. The focal point of this paper is the collective knowledge content within the R&D capabilities, which is the hardest to transfer (Spender, 1996).

Data Analysis

The main purposes of data analysis in theory-building case studies are sharpening constructs and shaping propositions (Eisenhardt, 1989). To achieve these purposes, we used both in-depth within-case analysis and cross-case comparisons to analyze field findings. We first empirically refined constructs of the first set of strategic choice: collective teaching vs. fragmented teaching, and then moved on to inductively derive propositions relating this strategic choice with the perceived effectiveness of capability transfer activities. We repeated these steps for the other set of strategic choices: collective learning vs. fragmented learning.

Under each discussion topic, we analyzed related case findings and interview transcripts, which either confirm or expand the tentative constructs definitions or initial expectations of the relationship between constructs and effectiveness of capability transfer activities. Within-case analysis was done through pooling responses of different respondents about one case, and then generating an encompassing view of the case. We used cross-case analysis to analyze how the respondents compared various R&D capability transfers and knowledge transfer strategies that they had experienced personally. We also compared relevant literatures to our findings to strengthen literal validity and widen generalizability (Eisenhardt, 1989). The analytical process was highly iterative between cross-case analysis and the generalization of constructs and propositions. For the sake of clarity, we will focus on the final steps of the analytical process rather than present every step of the iteration process.

FINDINGS

We present the findings in two major sections, strategies of transferring collective knowledge from a (1) teaching perspective and (2) learning perspective, in line with the tentative propositions we posed. In each section, we first present representative case findings under the categories, which we derived through iterative within-case and cross-case analysis. We then describe relevant literatures to support the case findings. Finally, we arrive at a set of general propositions, which emerged from the cases.

I. Strategies of Transferring Collective Knowledge from the Teaching Perspective

The Constructs of Collective Teaching and Fragmented Teaching

At the beginning of this inquiry, we tentatively defined collective teaching as involving the trainees in a learning-by-doing project in the working environment of the source community. From the case analysis, we realize that this is only a necessary condition.

The sufficient conditions for collective teaching include two aspects. First, the source community should allow the members of the recipient community access to the source community's day-to-day working environment and opportunities to observe their ways of conducting business. Second, the members of the recipient community, upon given such access, must have enough intent and communication ability to interact with the members of the source community, while observing and reflecting on what they do and why they do it that way.

Overseas training of the Chinese employees in the home base of the foreign partner of the joint venture does not always mean collective training. For example, a Delphi joint venture has sent many of its Chinese engineers to its home base in the U.S. for three-month in-class training. During this training, the Chinese trainees received instructions from many Delphi experts, but did not have access to the day-to-day working environment of the source community. This kind of training falls into the category of fragmented teaching.

On other occasions, even though Chinese trainees gained full access to the source community when they participated in overseas training, because of their lack of intent or communication capabilities, they did not gain as much collective knowledge as they might have had they been able to learn from the entire source community. A Chinese manager from Delphi-China who went through on-job training in Delphi's home base in the U.S. had the following observation, "Some Chinese engineers did not learn much during the overseas on-job training because of their language problem 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." She further commented on her own experiences, "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."

From this and other similar examples, we slightly revise our definition of collective and fragmented teaching. We now view collective teaching as a process in which trainees are exposed to the working environment of the source community and are encouraged to engage in deep and broad interactions with relevant members of the source community for an extended period of time. As a polar opposite of collective teaching, we define fragmented teaching as a process in which trainees are not exposed to the working environment of the source community, but only are given instructions and coaching from individual members of the source community.

Comparison Between Collective Teaching and Fragmented Teaching

The study suggests two insights concerning collective and fragmented teaching. First, fragmented teaching is broadly used and, indeed, is the "base option" for transferring R&D capabilities in almost all cases. Second, the importance of collective teaching is widely acknowledged and the practice of collective teaching exists in all the companies we studied, although to different degrees.

The R&D projects in the companies we studied have been mainly "intermediate-stage" or "final-stage" R&D (Buckley & Casson, 1976). The projects include modifying or localizing peripheral component design based on the vehicle platform designed by the source partner, in order to adapt local road conditions, safety and environment regulations, and modifying styling to meet local consumers' taste. Although local R&D is not at a full-scale platform design (a platform usually takes billions of dollars to develop and requires a volume of over one million cars a year to offset the research cost), the work involves almost every stage of R&D from market research to concept design to prototyping and validation. The R&D capabilities to be transferred involve a high level of collective knowledge content. A Chinese top manager in product development in Shanghai-VW described the typical understanding about 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 guilds the various tasks, timelines, budgeting and specifications for different function groups and coordination among these groups. R&D capabilities also imply how effective 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." This is a clear indication that collective content is significant in R&D capabilities that the firms want to develop in these local companies.

We expected that collective teaching is a more effective mechanism in transferring collective knowledge and would be adopted by companies that transfer R&D capabilities with high collective knowledge content. Most interviews confirm this view.

The case that involves the greatest investment for developing local R&D capabilities is Shanghai –VW's 41-person overseas training program, which cost Shanghai-VW 1.8 million marks. The goal of this project was to develop state-of-the-art R&D capabilities that span all stages and aspects of vehicle development process within and through the team of 41 young managers and engineers, who were selected carefully by the Shanghai-VW's human resource department. Twenty of the managers went to Germany for training in August 1998. The second lot of 21 personnel went to Germany in September 1999. Upon their arrival in Germany, the trainees first engaged in a six-month study of the German language and their own specialty in a German university. They then transferred to VW AG's vehicle development department to receive training and participated in R&D projects, which included development of complete vehicle, styling, chassis, engine, and body, as well as computer related projects. This on-job training in Germany lasted for one year. Then the trainees then returned to Shanghai-VW and worked on local projects for a year. After that, they then returned to VW AG in Germany to finish the last half year of the three-year training program. Before being sent to Germany, every trainee signed a 15-year employment contract with Shanghai-VW to ensure that they will not terminate the training before completion or leave Shanghai-VW soon after the training ends.

In addition to Shanghai-VW, all other cases we studied engaged in collective teaching to different extents. Appendix II provides more details about the collective teaching mechanisms the firms used.

In general, each company we studied applied a mixture of fragmented and collective teaching during the transfer of R&D capabilities. Previous empirical studies also presented cases where a mixture of collective and fragmented teaching mechanisms were applied in transferring organizational capabilities. For example, Brewer and Nollen described three mechanism adopted by a HP-HCL (India) joint venture in transferring tacit and group-embedded process knowledge in the early years of the joint venture: (1) teams of 10 HCL–HP engineers regularly spent 3 to 12 month periods at HP's European headquarters in Germany, (2) a senior HP manager was the head of manufacturing at HCL–HP for 3½ years, (3) an HP expatriate was head of R&D at HCL–HP, and (4) several other HP technical experts were located in the joint venture in India (Brewer et al., 1998). Among these mechanisms, the first is collective teaching, the rest fall into the category of fragmented teaching.

When asked to compare collective teaching with fragmented teaching in their effectiveness for transferring R&D capabilities, respondents from different companies several knowledge-related advantages that collective teaching offers over fragmented teaching. From these data, we used an open coding process (Strauss & Corbin, 1990) to identify three categories of knowledge-related advantages of collective teaching: (1) tacit procedural knowledge within a single function, (2) tacit procedural knowledge across various functions, and (3) communal culture and mindset. All three categories share the conceptual underpinning of collective knowledge, because each has both tacit and group-embedded dimensions.

In the first category (single-function tacit procedural knowledge), respondents mentioned that collective teaching has advantages such as knowing the engineering language, getting better views about engineering problems, and obtaining more in-depth and situational understanding about solving problems in product design. In the second category (multiple-function tacit procedural knowledge), the respondents brought up the benefits of collective teaching, such as understanding the ways of cross-functional coordination and the overall framework of R&D processes. In the third category (communal mindset), respondents mentioned that they learned company and group culture, as well as the mindsets and heuristics underlying team decision making as benefits of collective teaching over fragmented teaching.

An interesting finding from the fieldwork is that collective teaching enables members of the recipient community to identify and eliminate that part of the collective knowledge they have learned is idiosyncratic to the source community's context before they transfer that knowledge back to the recipient community. As a Chinese engineering manager from Delphi-China observed, "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 removed it before the procedure was transferred to China."

In some cases, respondents claimed that collective teaching is not just advantageous, but indispensable. A Chinese manager in the product development area of Shanghai-VW who participated the 41-person training program commented, "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." Similarly, a Chinese manager from Delphi-China mentioned, "Training overseas is absolutely necessary for Chinese employees. Had we not gone to US for on-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 Chinese engineering manager at PATAC expressed the same idea, "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 senior manager at Beijing Jeep also claimed that every Chinese engineer absolutely needs to go the foreign partner's home base to receive on-job training, and each training section should last long enough for the trainees to gain deep understanding about the how to conduct a full-scale design project.

The notion of collective teaching arises in several related literatures. Collective teaching is similar to Lave's "legitimate peripheral participation" (Lave et al., 1991), and Nonaka and Takeuchi's "spiral of organizational knowledge creation" (Nonaka et al., 1995) in that learning should involve participation in a community of practitioners. Previous empirical studies also provide examples of collective teaching. A good example of collective teaching is Honda's guest engineer program in which the company transfers organizational capabilities to its supplier-partners (MacDuffie & Helper, 1997). In this program, the supplier sends engineers to work on design for manufacturing issues with Honda's product designers.

Bridge Networks

A striking finding from the field extended the knowledge-related advantages of collective teaching. Besides acquiring the collective knowledge, a non-knowledge-related benefit of collective teaching exists. This benefit is the development of an inter-communal network between the source and recipient communities during the overseas on-job training process.

The field evidence suggests that working in the source community even for a short period of time can give members of the recipient community significant opportunities to interact with various experts at the source community. These interactions during the process of collective teaching can build two key elements for sustainable, high quality and timely communication network between the source and the recipient communities: (1) inter-personal trust, and (2) know-who, i.e., the understanding of who does what better and who is most willing to help. Trust based on personal contact can enhance the quality of knowledge flow (Kale, Singh, & Perlmutter, 2000) and the sustainability of the network, whereas know-who can optimize and shorten the route of inter-communal information search. Therefore, collective teaching fosters a trust-based and path-optimized knowledge-transfer infrastructure between the source and the recipient communities. We refer to the infrastructure as a *bridge network.*

A Chinese manager of Shanghai-VW who participated the 41-person training project brought up the issue of the bridge network as one of the key benefits of doing the overseas training, "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 three-year training. As the training coming 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."

In another case, a Chinese engineer of Delphi-China described the knowledge transfer importance of inter-personal trust and the bridge network, "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."

In a similar vein, a Chinese manager at PATAC gave high remarks to the value bridge network, "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*[2]. A good *guanxi* between a Chinese and an American personnel means a informal and high quality information channel between them."

A Chinese senior manager of Beijing Jeep also put great emphasis on inter-communal communication channels, "It is very important to know whom you should contact across the Pacific when a specific issue arises. Many solutions to technical issues can be boiled down to the communication between a Chinese engineer and an American engineer. If you don't know who is the best person to talk to for a specific issue, you are in big trouble".

Personal ties between members of source community and members of recipient community can form in many ways. The mechanisms include long-term assignment of expatriates from the source community to the recipient community, exchange of short-term visits by source and recipient community members, and collective teaching/long-term on-site training of the members of the recipient community.

Based on the interviews, the ties formed in the collective teaching case are the most extensive, sustainable, and tailored to the knowledge needs of the members of a recipient community. A bridge network is an inter-communal boundary-spanning infrastructure. It differs from a boundary-spanning individual in its flatness and short path distance between the person who holds the knowledge holder and the person who inquires about the knowledge. Boundary spanning individuals are strongly linked to their colleagues and have extensive links outside their subunits (Tushman & Scanlan, 1981). In the case of inter-communal knowledge transfer, 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.

Figure 1 shows the difference between these two inter-communal infrastructures, of individual boundary-spanners and bridge networks. Fragmented training usually entails sending expatriates from the source community to the recipient community, and thus fosters individual boundary spanner infrastructures, in which members of the recipient community must go through the boundary spanner to connect with relevant experts of the source community. Collective teaching, however, allows members of the recipient community to form direct ties with various experts of the source community.

In almost all the companies we studied, individual boundary spanners and bridge networks co-existed. As an engineer from Delphi-China explained, “In my daily work, for most of the time, I communicate with my American colleagues through email and telephone without going through any intermediate supervision. Sometimes I ask my American supervisors here in Delphi-China (expatriates) to help me locate the right person in the US to answer my questions or help to solve my problems.” When comparing these two types of boundary-spanning infrastructures, this engineer commented, “Certainly, the bridge network is more effective, because it is very important to know who is the best person to ask for help. My American colleagues have a very finely defined division of labor. If I did not find the right person to answer my question at the first time, chances are the question would be passed on to the second or even the third person. The more persons the question must pass through, the less the motivation to answer it, and thus the less likely it got answered. If the question is presented to a wrong person, you may either get a wrong answer or get no answer at all. So, if you have a bridge network, you would always get a right and prompt answer. Our American supervisors here in China have too many things to handle. In many cases they could not offer help or did not know the right person they could refer us to for help.” It is clear that, when it exists, the bridge network is superior to individual boundary spanners not only 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 collective teaching process.

Decades ago, organization scholars argued that key individuals are more cost effective than a widespread communication across organizational or communal boundaries (Arrow, 1974; March & Simon, 1958). Nowadays, with the help of information technology, a bridge network has become almost as affordable as or 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 the inter-communal boundary spanning infrastructures.

Situations Where Collective Teaching Is Not Preferred

The above discussion established that collective teaching is superior to fragmented teaching for two reasons: acquiring collective knowledge embedded in the source community, and establishing a bridge network between the source and the recipient community. Surprisingly, however, some cases reveal situations in which collective teaching is *not* preferred over fragmented teaching. In attempting to understand this seeming contradiction, we found an extension to our tentative expectation of the superiority of collective teaching.

Among situations where collective teaching is not preferred, we found two dominant reasons: transfer effort and limited group-embeddedness of R&D capabilities to be transferred. Obviously, when managers formulate knowledge transfer strategies, they must evaluate the financial cost and human effort of transfer (Teece, 1976), as well as the benefits of a particular strategy (Mason, 1980; Schwartz, 1982). We define *transfer effort* as a combination of financial cost and lost work hours from both the source and the recipient communities due to carrying out a certain capability transfer strategy. The benefit or need of using collective teaching increases with the level of group-embeddedness of the R&D capabilities to be taught is high. When the extent of need exceeds the level of effort, collective teaching will be adopted.

Figure 2 depicts a view of managerial choice in selecting teaching strategies for transferring a certain organizational capability. For simplicity, group-embeddedness of the organizational capability to be taught is denoted as Γ. In Zone I, where the level of Γ is low, the benefit for collective teaching is low, and using collective teaching to achieve the same objective of knowledge transfer that fragmented teaching can achieve is uneconomical. As the level of Γ

reaches Zone II, the benefit of collective teaching becomes significant. In other words, using fragmented teaching to attempt to achieve the objective of knowledge transfer will incur higher transfer effort than using collective teaching. To sum up, the higher the level of Γ, the more likely collective teaching is justified.

For example, one joint venture of Delphi-China produces electric wiring harnesses in China. The products are not sophisticated and design and manufacturing processes are not cross-functional or architectural. In other words, the level of Γ of this joint venture lies in Zone I. The training of Chinese engineers is done entirely in China, by fragmented training. 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. The level of Γ of its R&D capabilities to be transferred lies in Zone II. The Chinese employees of this division were sent to the home base of Delphi in the US for on-job training, which is collective teaching.

Propositions

Several propositions emerged from the discussions of collective and fragmented teaching.

Proposition 1a. In the context of acquiring organizational capabilities from the source community, collective teaching helps the recipient community acquire collective knowledge about the organizational capabilities of the source community.

Proposition 1b. In the context of acquiring organizational capabilities from the source community, collective teaching helps establish bridge networks, which provide communication channels between members of the source and recipient communities. In contrast to collective teaching, fragmented teaching fosters individual boundary spanner communication infrastructures, which are less effective than bridge networks in transferring collective knowledge.

Proposition 1c. In the context of acquiring organizational capabilities from the source community, the higher the group-embeddedness of the capabilities to be taught, the more likely collective teaching will incur lower transfer effort than fragmented teaching and will be adopted in practice.

Building on organizational learning arguments, we expected that collective teaching provides opportunities for the members from the recipient community to gain collective knowledge from the source community, which fragmented teaching cannot provide. The case evidence supports this expectation. Moreover, the case study identified the bridge network as another benefit of collective teaching. The case study also extended the initial expectation by introducing two factors that affect the practitioners' choice between collective and fragmented teaching – transfer effort and the level of group-embeddedness of the knowledge.

II. Strategies of Transferring Collective Knowledge from the Learning Perspective

Constructs of Collective Learning and Fragmented Learning

Teaching strategies deal with how individual members of the recipient community acquire knowledge from the source community. By contrast, learning strategies address how individual learning integrates and re-embeds into the recipient community and forms new collective knowledge adapted to the context of the recipient community. In short, teaching strategies relate to the knowledge acquisition aspect and learning strategies to the knowledge integration aspect of the knowledge transfer process.

In the theoretical foundation of this paper, we identified two categories of learning strategies: collective and fragmented learning. A question arises at this point, concerning the nature of collective learning. Does learning as a group necessarily means collective learning? In particular, all the companies we studied have sent their employees for in-class training or seminars for engineering or managerial courses. Is this training mechanism a type collective learning? The answer is no.

From the case evidence, two key characteristics of collective teaching emerged: *synchronization of learning* based on the pace of the R&D project that involved all trainees and *intense interaction* among trainees during the training process. Interactions among members of a recipient community lead to the formulation of transactive memory (Argote et al., 2000a; Wegner, 1987), interpretation scheme (Daft et al., 1984; Levitt et al., 1988), common language, and other group-level knowledge within this community (Brown et al., 1998; Cook et al., 1999). Therefore, we define *collective learning* as a knowledge integration process in which trainees are trained as a group with significant amount of interactions among each other such that transactive memories and other group-level knowledge can be formed among them. This is similar to Kasl et al.'s definition of synergetic team learning, which indicates "members create knowledge mutually" and "divergent perspectives are integrated through dialectical processes that create shared meaning schemes" (Kasl, Marsick, & Dechant,).

As a polar opposite of collective learning, we define *fragmented learning* as a knowledge integration process in which trainees' lack of either or both of the key characteristics of collective learning (i.e., synchronization of learning pace and significant interaction among learners). This is similar to Kasl et al.'s definition of the fragmented mode of team learning, which implies "individuals learn separately, but the group does not learn as a holistic system" (Kasl et al.,). Fragmented learning has been widely adopted by the practitioners in inter-organizational knowledge transfer according to previous empirical studies (Liebrenz, 1982; Reddy & Zhao, 1990). In most technology transfer agreements, the provision for training of the members in the recipient organization is stated in measures such as "person-month of on-site training", which does not specify whether the training is carried out collectively or individually.

Comparison Between Collective Learning And Fragmented Learning

To avoid confounding the effects of teaching and learning strategies, we compare collective learning and fragmented learning among cases that adopted collective teaching, i.e., local employees were sent to the home site of the source community for on-job training. Our goal is to see whether sending the local employees for overseas training at the same time and on the same project and with significant interaction among themselves (i.e., collective learning) is better than sending them for overseas training at different times, or on different projects, or without significant interaction among themselves (i.e., fragmented learning). Building on organizational learning literatures (Argote et al., 2000a; Brown et al., 1998; Kogut et al., 1992; Levitt et al., 1988), we expected collective learning to be more effective than fragmented learning in transferring collective knowledge. As Kogut has argued, "the teaching of know-how and information requires frequent interaction within small groups, often through the development of a unique language or code. Part of the knowledge of a group is simply knowing the information who knows what. But it also consists of how activities are to be organized, e.g., by Taylorist principles" (Kogut, 1992:389). The evidence of the case study enriched the orienting proposition by describing several benefits of collective learning over fragmented learning, as well as identifying conditions when fragmented learning dominates collective learning.

Among the cases we studied, the strongest case of collective learning is Shanghai-VW's 41-person overseas training project. A Chinese participant of this program described the nature of collective learning using a metaphor of "the coupling of two pyramids", saying that "Suppose that the R&D team of VW AG is like a pyramid, each building block representing a particular function and each layer of blocks representing a particular managerial level, we (i.e. the 41-person team) have trainees from each building block at each layer work in the corresponding block and layer of VW AG during our overseas training. It is as if our pyramid is coupled with theirs." In this training project, Chinese trainees not only worked in the unit of their specialty in VW AG with the German experts, but also communicated frequently with other Chinese trainees to coordinate related problems from the adjacent functions in the R&D process or to work on architectural or systemic issues in R&D, such as data structure of the entire design, and body/exterior dimensions, which 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-VW program informally interacted with each other 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 this informal interaction among Chinese trainees. To enhance the collective learning during the overseas training, the Chinese trainees also organized weekly meetings, to review what each one had learned in that week. "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", explained one Chinese trainee. Upon returning to Shanghai-VW, these 41 trainees formed the core of the local R&D force. The product development manager credited the recent success in developing many local variations of the new vehicle platform to the group-embedded R&D capabilities acquired from the 41-person training project.

In other cases, respondents also acknowledged the advantages of collective learning in cultivating the group-level knowledge. For example, respondents from both Delphi-China and PATAC mentioned that collective teaching helped them to cultivate cross-functional collaboration among Chinese trainees. A respondent from PATAC commented that collective teaching helped to develop a new culture that is neither Chinese nor American, but PATAC-specific. Respondents also noted that if the trainees went overseas at the same time but for different R&D projects, the coordination among the trainees would not be as strong as it would be when they went to same project.

From the case evidence we also identified another benefit of collective learning, efficiency of synchronization. In particular, if the trainees went overseas for training at different times, there would be times when those who had received training had to work with those who had not received training. Many respondents complained about the difficulty of knowledge sharing when this happened. The new ideas and mindsets brought back by those who completed overseas training could not be diffused smoothly to the rest of the recipient community, who had not acquired the mental framework needed to understand these ideas. A Chinese manager from Beijing Jeep (BJC) admitted, “The reason that we haven’t achieve 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 to BJC, they usually found that it was difficult to diffuse what they learned to their Chinese colleagues who had not gone there. Some aspects of R&D management cannot be communicated and promoted unless everyone understands the logic behind them.”

To sum up, if sufficient numbers of engineers and managers undertake overseas training at the same time and on same project, they gain group-level and synchronization benefits. They gain group-level knowledge, which helps them cooperate after the training period is over and re-embed the collective knowledge learned from the source community. In addition, they also reduce the friction of knowledge diffusion that arises from unsynchronized fragmented learning.

Some previous studies of group learning have identified benefits of collective learning. In an experiment of collective learning, for instance, Liang et al. (Liang, Moreland, & Argote, 1995) found that training employees in their work group as a whole is more effective than training the employees individually. This indicates that collective learning can foster collective memory and enable the development of collective knowledge more effectively.

Situations Where Collective Learning Is Not Preferred

Notwithstanding many benefits of collective learning, companies in this study other than Shanghai-VW has adopted only small-scale collective learning efforts, rather than large-scale programs. PATAC, Delphi-China and Beijing Jeep typically have sent their Chinese employees for overseas on-job training either individually or in small groups. The main factor that affects the selection of learning strategies, according to the respondents, is transfer effort. 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.”

From the evidence, we identified another factor that affects the selection of learning strategies, the need for future coordination among members of the recipient community, or in other term, the group-embeddedness of the collective knowledge to be re-embedded in the recipient community. As a Chinese manager from Delphi-China commented: “It is really costly to do collective learning. However, if future collaborations among a group of R&D engineers are really important, group-wide overseas training may be justified. In our case, each engineer is responsible for one project, and communicates with his customers or American counterparts more than he does with his Chinese peers. The cross-personal interaction among us is not very high. So we do not feel necessary to do a group-wide overseas training.”

Figure 3 provides a view of managerial choice in selecting learning strategies for transferring an organizational capability. For simplicity, group-embeddedness of collective knowledge to be re-embedded in the recipient community is denoted as $\mathbf{\Phi}$. In Zone I, where the level of $\mathbf{\Phi}$ is low, the need or benefit for collective learning is low, thus using collective learning to achieve the same objective of knowledge integration or re-embedment is uneconomical. As the level of $\mathbf{\Phi}$ moves to Zone II, the need or benefit of collective learning becomes significant, and using fragmented learning to achieve the objective of knowledge integration or re-embedment at a high level of $\mathbf{\Phi}$ will incur high transfer effort. In other words, the higher the level of $\mathbf{\Phi}$**,** the more likely collective learning will occur.

For example, most Delphi joint ventures emphasize enabling local engineers to coordinate effectively with their foreign counterparts, rather than developing local R&D capabilities. In these cases, the level of $\mathbf{\Phi}$ is low and lies in Zone I; these joint ventures do not engage in collective learning. In contrast, Shanghai-VW has set a clear objective of developing indigenous capabilities of developing and localizing vehicle designs. In other words, the expected level of $\mathbf{\Phi}$ is high and falls into Zone II. Collective learning was adopted as the Chinese R&D engineers were sent to VW AG for on-job training as a team.

Propositions

Several propositions emerged from the discussions of collective and fragmented learning.

Proposition 2a. In the context of integrating and re-embedding organizational capabilities in the recipient community, collective learning assists prompt development of group-level knowledge (such as routines and transactive memories) required for future collaboration within the recipient community.

Proposition 2b. In the context of integrating and re-embedding organizational capabilities in the recipient community, collective learning offers advantages of synchronized learning.

Proposition 2c. In the context of integrating and re-embedding organizational capabilities in the recipient community, the higher the group-embeddedness of collective knowledge, the more likely collective learning will incur lower transfer effort than fragmented learning and will be adopted in practice.

In this section, we considered the superiority of collective learning over fragmented learning in transferring collective knowledge. The case evidence supports the expectation, drawn from organizational learning theory, that collective learning can provide opportunities for the members from the recipient community to re-embed collective knowledge learned from the source community into the recipient community. The case study also extended the initial expectation by introducing two factors that affect the decision makers' choice between collective and fragmented learning – transfer effort and the group-embeddedness of collective knowledge to be re-embedded in the recipient community.

DISCUSSIONS AND CONCLUSIONS

This study explores strategic issues in inter-communal transfer of collective knowledge with a group-level epistemological perspective (Cook et al., 1999). Aligned with the group-embeddedness dimension of collective knowledge, the group-level perspective directs our attention to both the source and recipient communities, and further leads to two sets of strategic choices concerning the transfer of collective knowledge from both teaching and learning perspectives: *collective vs. fragmented teaching*, and *collective vs. fragmented learning*. The theory-guided inductive approach ensures a solid connection among initial theoretical expectations, empirical findings, and the empirically validated theoretical framework.

The transfer of organizational capabilities across group boundaries implies two essential aspects: (1) acquiring group-embedded tacit knowledge of the source community by the individual learners of the recipient organization, and (2) integrating and re-embedding the individual learning among the learners to form the capabilities needed within the recipient community (Levitt et al., 1988). Different teaching and learning strategies address different needs for knowledge acquisition and knowledge integration. Although we discussed these strategies separately for the clarity in concept development and framework explanation, in practice every capability transfer event involves both knowledge acquisition and knowledge integration and thus requires a combination of teaching and learning strategies.

Figure 4 depicts four different configurations of teaching-learning strategies. The choice of teaching strategies is orthogonal to that of the learning strategies. In other words, adopting collective teaching in a capability transfer project does not necessarily demand the adoption of collective (or fragmented) learning in the same project. Each configuration may imply multiple strategic mechanisms in practice. The figure lists typical examples of mechanisms. For a capability transfer event, depending on the extent of group-embeddedness of the collective knowledge to be taught and the that to be re-embedded in the recipient community, teaching and learning strategies will be selected based on the transfer effort required for the configuration.

Contributions and Empirical Implications

There are three key findings. First, collective teaching, or having members of the recipient community work in the source community for an extended period, helps members of the recipient community understand the collective knowledge embedded in the source community. This opportunity will not be available if firms adopt only fragmented teaching. This finding confirms the theoretical expectation derived from organizational learning theory.

The second finding is a surprise from the field. Comparing to fragmented teaching, collective teaching offers the additional benefit of cultivating a bridge network, which serves as a direct, trust-based, and sustainable communication infrastructure between the source and the recipient communities. Fragmented teaching alone, by contrast, fosters individual boundary spanner communication infrastructures, which often are indirect and less tailored to the needs of the knowledge recipients. This finding leads to a theoretical recombination of epistemology and network arguments, and suggests that when studying the outcome of knowledge transfer activities, one should look for not only knowledge-related outcomes, but also communication infrastructure-related outcomes.

The third finding is that collective learning enhanced the re-embedding of collective knowledge acquired from the source community into the recipient community. This confirms the theoretical expectation derived from organizational learning theory.

At a more fundamental level, two overarching frameworks emerged from the empirical insights. In the practice of knowledge transfer, cost-effectiveness is a major concern of the practitioners. The level of group-embeddedness of the knowledge to be transferred affects the relationship among the transfer effort of different types of transfer strategies. The first framework (Figure 2), relates transfer effort of various *teaching* strategies and the level of group embeddedness of capability to be taught (Γ), and indicates that the higher the level of Γ, the more likely that collective type of teaching strategy will become more cost-effective than fragmented type of teaching strategy. Similarly, the second framework (Figure 3), relates transfer effort of various *learning* strategies and the level of group embeddedness of capability to be re-embedded into the recipient community (Φ), and indicates that the higher the level of Φ, the more likely that collective type of learning strategy will become more cost-effective than a fragmented learning strategy. We note, however, that when the framework indicates that collective teaching (or learning) incurs less transfer effort than fragmented teaching (or learning), collective teaching will not necessarily replace fragmented teaching. Instead, in practice, collective teaching usually serves to supplement the more common fragmented teaching as need arises.

The empirical setting of this study is significant in its own right. The auto industry is the pillar industry of China and the Chinese auto market is the largest growing market in the world. As China's WTO entry approaches, one of the urgent items for multinational firms' operations in China is to develop local R&D capabilities. Previous empirical studies show that personnel from less developed countries need not only a broad coverage of various stages and aspects of project preparation, implementation and operation, but also need a higher level understanding of why things are managed in certain ways (Marton, 1986). This study provides practitioners with a rich description of the best practices and lessons learned in transferring organizational capabilities and, moreover, a theoretical framework that can help them to formulate their own strategies for transferring organizational capabilities**.** Although the research setting is about R&D capability transfer in Chinese auto industry, the logic can be directed at more general issues of enabling factors for effective inter-communal transfer of collective knowledge, through the use of analytic generalization in case methods (Yin, 1981). Literature enfolding also enhances the level of generalizability (Eisenhardt, 1989).

The empirical implications of this study lie in two aspects: (1) explaining the success or failure of the past events of capability transfer and (2) providing guidelines for practitioners to formulate future capability transfer strategies. Both practitioners and theorists have realized the enormous difficulties and high rate of failures in transferring capabilities either across the boundary of business lines or across the boundary of organizations. The study indicates that root causes of transfer failure lie in the areas of knowledge acquisition and knowledge integration. If the teaching and learning strategies are formulated according to the group-embeddedness of the capabilities to be taught and to be re-embedded, the chance of failure will decline.

Limitations And Future Research

There is much room for future work to build on this exploratory study. We note two issues. First, measures such as transfer effort, scale of collective teaching and learning, and the level of group-embeddedness of knowledge to be transferred or re-embedded need to be further sharpened and operationalized for theory testing. Second, we did not examine the coupling effect of teaching strategies and learning strategies. Each organization we studied typically used a mixture of these configurations. In the future research, each configuration deserves separate study, while the relationships among these configurations with regard to the transfer effort and sequence of usage also merit close examination.

Endnotes

1. Spender uses a “social/individual” distinction instead of “group/individual”, emphasizing overall embeddedness rather than the distinction between communal and social embeddedness. We consider that the term collective knowledge can mean group tacit knowledge, in the group genre of Cook and Brown (Cook et al., 1999).

2. Guanxi is the Chinese word for “personal relationship” (see Tsui & Farh, 1997; Luo, 1997).

REFERENCES

Almeida, P. & Grant, R. M. 1998. International corporations and cross-border knowledge transfer in the semiconductor industry. A Report to the Carnegie-Bosch Institute, March.

Amit, R. & Schoemaker, P. J. H. 1993. Strategic Assets and Organizational Rent. Strategic Management Journal, 14: 33-46.

Araujo, L. 1998. Knowing and learning as networking. Management Learning, 29(3): 317-336.

Argote, L. & Ingram, P. 2000a. Knowledge Transfer: A basis for competitive advantage in firms. manuscript.

Argote, L., Ingram, P., Levine, J. M., & Moreland, R. L. 2000b. Knowledge transfer in organizations: Learning from the experience of others. Organizational Behavior and Human Decision Process, 82: 1-8.

Argyris, C. & Schon, D. A. 1978. Organizational learning. Reading, MA: Addison-Wesley.

Arrow, K. J. 1962. The economic implications of learning by doing. Review of Economic Studies, 28: 155-173.

Arrow, K. J. 1974. The limits of organization. New York: Norton Co.

Beamish, P.W. 1993. The characateristics of joint ventures in the Peoples' Republic of China, Journal of International Marketing, 1(2) 29-48.

BIC, B. I. C. 1992. Managing a successful global alliance. New York: Business International Corporation.

Brewer, T. L. & Nollen, S. D. 1998. Knowledge transfer to developing countries after WTO: Theory and practice in information technology in India. *Report to the Carnegie Bosch Institute*, *Working Paper 98-1*4.

Brown, J. S. & Duguid, P. 1998. Organizing knowledge. California Management Review, 40(3).

Buckley, P. J. & Casson, M. C. 1976. Chapter 2. A long-run theory of the multinational enterprise, In The future of the multinational enterprise. London: Holms & Meier.

Child, J. and Y. Yan, 2001. National and transnational effects in international business: Indications from Sino-foreign joint ventures, Management International Review, 41(1), 53-70.

Conner, K. R. & Prahalad, C. K. 1996. A resource-based theory of the firm: Knowledge versus opportunism. Organizational Science, 7(5): 477-501.

Cook, S. D. N. & Brown, J. S. 1999. Bridging epistemologies: The generative dance between organizational knowledge and organizational learning. Organization Science, 10(4): 381-400.

Daft, R. L. & Weick, K. E. 1984. Toward a model of organizations as interpretation system. academy of Management Review, 9(2): 284-295.

Dierickx, I. & Cool, K. 1989. Asset Stock Accumulation and Sustainability of Competitive Advantage. Management Science, 35(12): 1505-1513.

Dussauge, P., Garrette, B., & Mitchell, W. 2000. Learning from competing partners: outcomes and durations of scale and link alliances in Europe, North America and Asia. Strategic Management Journal, 21(2): 99-126.

Eisenhardt, K. 1989. Building Theory from case study research. California Management Review, 14(4): 532-550.

Fiol, C. M. & Lyles, M. A. 1985. Organizational learning. Academy of Management Review, 10(4): 803-13.

Grant, R. M. & Baden-Fuller, C. 1995. A knowledge-based theory of inter-firm collaboration. Academy of Management, Best Paper Proceedings: 17-21.

Gupta, A. K. & Govindarajan, V. 2000. Knowledge flows within multinational corporations. Strategic Management Journal, 21(4): 455-472.

Hedberg, B. 1981. How organizations learn and unlearn? In P. C. Nystrom & W. H. Starbuck (Eds.), Handbook of organizational design: 8-27. London: Oxford University Press.

Henderson, R. M. & Clark, K. B. 1990. Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms. Administrative Science Quarterly, 35(1): 9-30.

Inkpen, A. C. 1997. An examination of knowledge management in international joint ventures. In P. W. Beamish & J. P. Killing (Eds.), Cooperative strategies: North American perspectives. San Francisco: The New Lexington Press.

Inkpen, A. & Dinur, A. 1998. The transfer and management of knowledge in the multinational corporation: Considering context. Carnegie Bosch Institute Working Paper.

Kale, P., Singh, H., & Perlmutter, H. 2000. Learning and protection of proprietary assets in strategic alliances: Building relational capital. Strategic Management Journal, 21(3): 217-237.

Kasl, E., Marsick, V., & Dechant, K. Teams as learners. Journal of Applied Behavioral Science: 227-246.

Kogut, B. & Zander, U. 1992. Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. Organization Science, 3(3): 383-397.

Kostova, T. 1998. Success of the transnational transfer of organizational practices within multinational companies. Carnegie Bosch Institute Working Paper.

Lave, J. & Wenger, E. 1991. Situated learning: Legitimate peripheral participation. Cambridge: Cambridge University Press.

Leonard-Barton, D. 1992. Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development. Strategic Management Journal, 13(special issue, Summer): 111-126.

Levitt, B. & March, J. 1988. Organizational Learning. Annual Review of Sociology, 14: 319-40.

Liang, D. W., Moreland, R., & Argote, L. 1995. Group versus individual training and group performance: The mediating role of transactive memory. Personality and Social Psychology Bulletin, 21(4): 384-393.

Liebrenz, M., L. 1982. Transfer of Technology - U.S. Multinationals and Eastern Europe. New York: Praeger.

Lu, J.A. 2001. Grafting and Innovation - Cases of joint venture management in Shanghai Automotive Industry Corporation (Group). Shanghai: Shanghai Finance and Economics University Press.

Luo, Y. 1997. Guanxi and performance of foreign-invested enterprises in China: An empirical inquiry. Management International Review, 37(1): 51-70.

MacDuffie, J. P. & Helper, S. 1997. Creating lean suppliers: Diffusing lean production through the supply chain. California Management Review, 39(4): 118-151.

March, J. G. & Simon, H. A. 1958. Organizations. New York: John Wiley.

Mason, R. H. 1980. A comment on Professor Kojima's "Japanese type versus American type of technology transfer. Hitotsubashi Journal of Economics(February): 42-52.

Nelson, R. R. & Winter, S. 1982. An Evolutionary Theory of Economic Change (First ed.). Cambridge, Massachusetts, and London, England: Harvard University Press.

Nonaka, I. & Takeuchi, H. 1995. The knowledge-creating company: How Japanese companies create the dynamics of innovation. New York, Oxford: Oxford University Press.

Penrose, E. 1959. The Growth of the Firm (First ed.). White Plains, New York: M. E. Sharpe.

Polanyi, M. 1962. Chapter 4: Skills, Personal knowledge. New York: Harper and Row.

Reddy, N. M. & Zhao, L. 1990. International technology transfer: A review. Research Policy, 19: 285-307.

Rouse, M. J. & Daellenbach, U. S. 1999. Rethinking research methods for the resource-based perspective: isolating sources of sustainable competitive advantage. Strategic Management Journal, 20(5): 487-494.

Schwartz, K. 1982. HP-Grenoble: Case study in technology transfer. California Management Review, 24: 43-50.

Singh, K. 1995. The impact of technological complexity and interfirm cooperation on business survival, Academy of Management Journal; Best Papers Proceedings 1995, 67-93.

Spender, J. C. 1996. Making knowledge the basis of a dynamic theory of the firm. Strategic Management Journal, 17(Winter special issue): 45-62.

Spender, J. C. & Grant, R. M. 1996. Knowledge and the firm: Overview. Strategic Management Journal, 17(Winter special issue): 5-9.

Strauss, A. & Corbin, J. 1990. Basics of Qualitative Research: Grounded Theory Procedures and Techniques. New Park, London, and New Delhi: Sage Publications.

Szulanski, G. 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. Strategic Management Journal, 17(Winter): 27-43.

Teece, D. J. 1976. The multinational corporation and the resource cost of international technology transfer. Cambridge, MA: Ballinger Publishing Company.

Teece, D. J. 1986. Transaction cost economics and the multinational enterprise: An assessment. Journal of Economic Behavior and Organization: 21-45.

The State Administration of Machinery Industry, P. R. C. 1995. Policies about China automotive industry.

Tiemessen, I., Lane, H. W., Crossan, M. M., & Inkpen, A. C. 1997. Knowledge management in international joint ventures. In P. W. Beamish & J. P. Killing (Eds.), Cooperative strategies: North American perspectives. San Francisco: The New Lexington Press.

Tsui, A. & Farh, J.-L. L. 1997. Where guanxi matters: Relational demography and guanxi in the Chinese context. Work and Occupations, 24(1): 56-79.

Tushman, M. L. & Scanlan, T. J. 1981. Characteristics and external orientations of boundary spanning individuals. Academy of Management Journal, 24(1): 83-98.

Wegner, D. M. 1987. Transactive memory: A contemporary analysis of the group mind. In B. Mullen & G. R. Goethals (Eds.), Theories of group behavior: 185-208. New York: Springer-Verlag.

Yin, R. K. 1994. Case study research: Design and methods (second ed.). Thousand Oaks, London, New Delhi: Sage Publications.

Yin, R. K. 1981. The case study crisis: Some answers. Administrative Science Quarterly, 26(March): 58-65.

Appendix I. Chinese Auto Industry And The International Transfer Of R&D Capabilities

As we noted earlier, we selected the activities of transferring R&D capabilities in Chinese auto industry as the empirical setting for this study. There is growing evidence that MNEs transfer R&D capabilities to their joint ventures in this industry. Moreover, there are significant technological, cultural, and managerial distances between the source organizations, which are foreign MNEs, and the recipient organizations, which are the IJVs of the MNEs in this industry. This large asymmetry between the two alliance partners indicates substantial potential for inter-partner learning (Dussauge, Garrette, & Mitchell, 2000). The industry provides a natural setting for studying how firms apply their network knowledge stock and design their inter-partner network structure to overcome transfer difficulties and achieve effective capability transfer.

When China's auto industry opened to foreign investors in the early 1980's, its R&D capability in passenger car sector was weak. State owned enterprises (SOEs) in this sector were initially formed to produce commercial vehicles rather than passenger vehicles. SOEs were characterized by low R&D effort (R&D spending was less than 1% of revenue, far lower than R&D by MNEs) and long platform upgrade cycles (usually longer than 20 years).

The Chinese government considers the auto industry as a pillar industry and Chinese industrial policy gives strong emphasis on developing indigenous R&D capabilities. The approval guidelines for foreign MNEs' to establish IJVs in the Chinese auto industry involve several key provisions concerning technical development (The State Administration of Machinery Industry, 1995). The IJV must have an internal technical center, which is capable of developing future generations of products. Moreover, the products of the IJV must quickly reach global technological levels. The industrial policy makers of this industry also gave strategic guidelines for developing indigenous R&D capabilities (The State Administration of Machinery Industry, 1995): (1) vehicle OEMs should take 5% to 10% of total reinvestment into developing or expanding their tech centers; (2) R&D spending should reach 2% to 3%of sales; and (3) key component suppliers should apply 10% to 20% of their reinvestment to set up their R&D facilities and technical centers. The government also provides financial and taxation support for joint R&D projects among business groups.

MNEs have recognized the potential of the emerging car market in China since the early 1980s. AMC-Jeep (later acquired by Chrysler) and VW were the first two MNEs to enter China. They entered with cautious attitudes about the industrial infrastructure and local market, and only established simple vehicle assembly facilities with low local content and near-to-zero local knowledge content. The big commercial success of VW in the late 1980s and early 1990s evoked an inflow of foreign investment in both vehicle OEM and supplier sectors. In order to earn the approval to enter China, MNEs now must commit to bring in modern product/process technologies and help develop indigenous R&D capabilities at their local operations.

China's demand for R&D capability transfer does not necessarily contradict with the long-term vision of MNE investors. As competition in the host countries' markets becomes more global and intense, new products that suit local tastes and regulations need to be developed at a faster pace. Transferring R&D capabilities to operations close to local markets then becomes beneficial (Buckley et al., 1976). MNEs' R&D activities in the LDCs are mostly at the end stage of the R&D cycle, with tasks such as adapting the general design to the local environment validating the product capability of local supplier, and validating the localized product design to meet the quality, safety and environmental requirements. The design adaptation/localization process ranges from extending the length of the car to re-designing the exterior and interior. GM-Shanghai, for example, made over 600 engineering changes to tailor Buick Century to Chinese driver preference, road conditions, and local gasoline quality.

It is understandable that at the early stage of acquiring R&D capabilities, the recipient will not be entrusted with full-blown R&D projects for market purposes, even with the assistance of expatriates from the source firm. In the auto industry, R&D projects involve many different levels of difficulty. The most extensive R&D activity is the development of a new platform, which includes styling, redesign of power train and key subassemblies and components. This kind of project usually costs more than a billion dollars for each platform and needs production volume exceeding a million vehicles a year to recover the R&D costs. Obviously, this is not a feasible starting task for the recipient firm to work on. And, in reality, the source organizations, which usually are MNEs from the industrialized countries, do not intend to hand over knowledge of this kind of activity to their partners in LDCs. The realistic tasks for both the recipient and the source firms lie in the R&D activities with lower degree of difficulty and narrower scope. Most joint R&D tasks between local recipients and the multinational source firms in the Chinese auto sector limit themselves to recombining local knowledge with the MNE’s general knowledge, that is, to carry over an existing platform developed by the MNE and modify style, dimensions, and parameters of some components based on local customer taste, driving conditions, and government regulations. This type of task, although relatively simple, still calls for a great deal of coordination among functional groups such as marketing, analysis, design, prototype, validation, and production. Engaging in these tasks can expose the recipients to a large portion of R&D routines and different stages of R&D process.

Appendix II. Operating And Capability Transfer Practices Of The Companies

I. Shanghai-VW

Shanghai-VW, a joint venture among Shanghai Automobile Industrial Corporation (SAIC), Bank of China, China Automobile Industrial Corporation (CAIC), and VW AG, has a total employment of 10,000 and total registered capital of 2.3 billion RMB (277 million US dollars), in which VW has a 50% share. Its annual output reached 200,000 cars in 1999 and took over 60% of the market share in China's mid-size car sector. The duration for the initial joint venture contract is 25 years. Both Chinese and German partners are willing to extend the contract for another 25 years.

Shanghai-VW started its production in 1985 with a single product, Santana, which was an out-dated model even at the time of market introduction in China. However, due to the huge market demand and lack of sizable competitors in the local market, Shanghai-VW has enjoyed relatively secure market dominance and above-normal return without re-introducing a new car model until the mid-1990s. During the early years of Shanghai -VW, the venture devoted most effort to localizing component production, improving production management and quality, and reducing cost. In 1995, Shanghai -VW passed the QS9001 qualification. Its local content of production increased from less than 5% in 1985 to over 90% in 1997.

From the beginning of Shanghai-VW, both Chinese and German sides have had a clear vision of the importance of training the local engineering and technical force. Soon after Shanghai -VW was established, the German partner took the lead in developing and supervising training programs. A training center was developed with German investment of 1.63 million German marks and Chinese investment of 2 million RMB. This training center has been continuously refurbished and improved over the past few years. It is now the highest quality training facility in China's auto sector, with training capabilities for product, manufacturing, and R&D. The classes include CAD, exterior modeling, manufacturing technologies, automatic control, automotive electronics, engineering analysis, and network information systems. The training center has sent ten Chinese instructors to the training department of VW for training. By 1998, 1,060 Chinese personnel from Shanghai -VW had received technical training from the training center. Shanghai -VW's overall long-term training plan includes areas such as professional training, general training, project-focused training, on-job training, qualifying exams, leadership training, and overseas training (Lu, 2001). In addition to the in-class training, based on the technology transfer agreement of the JV, for every key technical collaboration projects between the Chinese and German partners, Shanghai -VW sends engineering and technical personnel to related VW engineering or manufacturing units for on-job training.

In mid-1990s, as more multinational auto manufacturers entered China through joint ventures, the local market competition heated up, which threatened Shanghai -VW's market dominance in China's mid-size car sector. After almost ten years' of single product operation, Shanghai -VW realized that it was time to introduce new generations of products. In 1997, a modified model of Santana and a Santana 2000 were introduced. The major work development of Santana 2000 was done in VW-Brazil. However, Chinese engineers in Shanghai -VW participated heavily in the exterior styling design of this car model.

As China's entry into WTO approaches, Shanghai -VW realizes that product development cycle must significantly shortened, and the cost for new product launching must be significantly reduced. This new challenge has led Shanghai -VW to shift more strategic emphasis toward developing local R&D capabilities. A ten-year plan for developing local R&D capabilities has been established and launched. The goal is to bring the local R&D capabilities to a higher level in order to achieve concurrent and multiple-project R&D, i.e., "manufacturing generation I, developing generation II, and planning for generation III simultaneously". As a first step, SHANGHAI-VW invested 0.8 billion RMB (about 100 million US dollars) to expand its technical center to include prototyping and testing facilities that are indispensable to the vehicle development. At the next stage, taking the joint development of the Chinese version of Passat, a popular compact car initially developed in Germany as a learning platform, Shanghai -VW engaged in a large-scale knowledge transfer campaign, which involves Chinese personnel from plant floor to top management, including 765 persons or 1,660 person-month overseas training. The major R&D work on the Chinese version of Passat is in exterior and body extension. German engineers do the major design work and technical validation in Germany, Chinese engineers from Shanghai-VW participated in design proposal stage. Some state-of-art CAD tools, such as dynamic structural design are used in the Passat project. There are 450 R&D-related personnel in Shanghai -VW, whereas in VW AG there are over 8,000. Shanghai -VW plans to increase R&D-related personnel to 1,000 over the next 4 or 5 years.

II. Delphi-China

Delphi Automotive Systems is the world's largest auto supplier. It established a representative office in Beijing in 1994, while Delphi was still part of the General Motors Corporation. Since then, Delphi has established 9 joint ventures and 3 wholly owned enterprises in China. The main purpose of these operations is to supply to the Chinese operations of its OEM customers, such as GM-North American operation and GM-Opel. By the end of 2000, Delphi's overall investment in China exceeded 400 million US dollars, while its total sales also reached 400 million US dollars. The products in its Chinese operations range from electronic instruments and batteries to brakes and steering systems. In 1999, the holding company of all Delphi's Chinese operations was established in Shanghai.

Delphi has been developing its Chinese business based on five principles: (1) long-term cooperation, (2) actively transferring technologies, (3) promoting localization of design and production, (4) promoting internationalization through exporting, and (5) serve multiple OEMs. In order to better transfer technologies and localize design, Delphi cooperated with Tsinghua University, a leading university in China, and established Delphi-Tsinghua Institute (DTI) in 1996 in Beijing. DTI offers a large range of technical and managerial training programs, such as ISO/QS quality systems, lean manufacturing, automotive engineering, leadership, human resources, project management, and corporate culture. The trainers of DTI include professors from Tsinghua University, Peking University, Chinese Academy of Science, and experts from Delphi Automotive Systems. By June of 2000, DTI has provided training for over 8,000 person-weeks for more than 200 customers. DTI serves as "the premier training center in China, bridging industry, government and academia to meet their needs."

Besides DTI, Delphi also uses other mechanisms to transfer technologies and capabilities to its Chinese operations. Depending on the need of individual operations, some of Delphi's China operations invite foreign experts to be managers and trainers in China, some send Chinese engineers and managers for overseas training in Delphi's various divisions around U.S., and some use both approaches. Delphi Parker-Shanghai, which produces electric harnesses, adopted an all-American managerial team at the beginning. An American manager, who was also responsible to mentor his/her Chinese successor, headed every functional unit. In about six months, half of the American managers finished their mentoring job and transferred their leadership to Chinese successors. Now, Chinese nationals fill almost all mid and low-level managerial jobs. Delphi-Steering Systems, which produces steering systems and half shafts, has sent all of its Chinese engineers and managers to its home base in Saginaw, Michigan for on-job training, ranging from 3 months to over a year. In contrast, Delphi-Energy, which produces engine accessories, did not send its Chinese engineers for overseas training.

III. PATAC

GM entered China in 1997 with five principles: (1) GM is committed to China for the long term in a relationship that benefits GM, China and the Chinese people, (2) GM is involved in the production, distribution, design and testing of vehicles, (3) GM is actively engaged in technology exchange programs needed to develop the Chinese automobile industry, (4) GM is committed to fostering the managerial and professional skills of its local Chinese employees, and (5) GM ensures its operations in China are globally integrated to secure the highest quality, services and products for the Chinese market. Based on the fourth and fifth princes, GM not only set up two manufacturing joint ventures, but also a R&D joint venture – Pan Asia Technical Automotive Center (PATAC), which is a US $50 million, 50-50 automotive engineering and design center joint venture between GM and Shanghai Automotive Industry Corporation (SAIC). The goal for establishing PATAC is to develop and expand China's automotive engineering and design capabilities while serving as an advanced technical center for the region. Acting as a fully separate business entity from its parents, 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. Its facilities are available not only to GM and SAIC but also to all automotive companies in China and the Asia-Pacific region. PATAC has about 250 employees, including 160 engineers, designers, scientists, and technicians. Many of these professionals have been drawn from auto manufacturers in the area. However, the Center has an open employment policy that allows it to hire overseas trained personnel to keep the Center ahead of technical advances.

In June 1999, PATAC unveiled its first small-size concept car, Qilin, representing a major accomplishment for automotive design in China. Qilin was designed to demonstrate the full range of design and testing capabilities offered by PATAC. Soon after the completion of Qilin project, the same team of R&D personnel engaged in a localization R&D project based on an existing small-size car, Corsa, which was developed originally in Europe. The localization R&D involves tasks such as redesigning heating and air conditioning system, as well as modifying engine control system to fit local road and fuel conditions and meet local regulations. The localized Corsa is named Sai-ou, and was successfully launched for production in 2001.

IV. Beijing Jeep

Beijing Jeep Corporation Ltd (BJC) is a 58-42 joint venture between Beijing Auto Work (BAW) and Daimler-Chrysler. BJC employs 8,200 personnel, in which about 10 managers and engineers are expatriates from Daimler-Chrysler. Before the formation of BJC, its Chinese partner had been producing an off-road vehicle without major design change from 1964 to 1984. Developing a new generation of off-road vehicle that suits the Chinese market was an urgent task for BAW, and was written as a key provision into the joint venture contract between the two partners of BJC. Soon after the formation of the BJC, a team of Chinese engineers was sent to the tech center of AMC in Detroit, with a plan to use the platform design of the American partner's CJ-7 to develop an off-road vehicle platform that suited the Chinese market. However, the design effort failed. According to the Chinese R&D manager, the failure was due to an inability to assimilate the vehicle design.

In 1988, BJC developed an off-road vehicle based on an existing truck platform from AMC, but ended at the concept stage. Four years later, BJC took on another round of R&D effort. This time, it spent 15 months and 2.8 million US dollars and utilized Chrysler's core platform design and R&D process. This effort again ended without commercialization because the design could not meet with the market and cost requirement, but the engineers agree that this R&D project gave them invaluable experiences in R&D management and the understanding of core technologies of the platform on which they would base their modified design.

From 1984 to 1996, BJC made multiple efforts to develop the next generation off-road vehicle with the help of the American partner and other foreign design companies. Although the task goal was not fulfilled, BJC accumulated experiences in vehicle design and R&D project management. The most valuable outcome of these efforts, according the R&D manager of the CP, is an experienced R&D team that can take on different functions of a R&D project. In articulating the content of the experience, this manager pointed out that it is the "stream of thought" in managing R&D processes, and the understanding of what design content of the original foreign product needs to be modified with the recombination of local market, supplier, and technological knowledge to generate a commercially viable product for the local market.

After a 12-year "learning period", BJC launched a new vehicle design project in 1996. This time, BJC adopted an advanced R&D management process to control timing, budgeting, and personnel movement, with the help of its American partner and other foreign design companies. The R&D project started from market research, and then entered into concept design stage with the concurrent collaboration among product design, quality control, finance, purchasing, and manufacturing departments. The design was proven and the first prototype vehicle was assembled and tested by the end of 1999. The formal production date was projected for 2002. Although the time taken for this round of R&D is long compared to current Western standards (2 to 4 years for new vehicle design), considering the amount of indigenous knowledge and managerial content that have been embedded into the new product and the extent of experience gained by the design team, this project was a major breakthrough for BJC.

During the 16 years of BJC, although the Chinese partner has had the intent of acquiring R&D capability, the joint management of the joint venture failed to formulate a systematic strategy on training R&D personnel. The joint venture has used three types of overseas training. The first type is overseas on-job training of teams of design managers and engineers with specific design projects, which can either for entire vehicle design or component design. The number of Chinese engineers in each training team ranges from 3 to 10, with the length of each training section span from 3 months to over a year depending on the size of the project. The second type of training is overseas formal engineering education but, in BJC's history, only eight Chinese engineers have received a one-year college-level engineering training from General Motors Institute (now, Kettering University). The third type of training involves 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 have received this type of assignment. In recent years, since Daimler acquired Chrysler, overseas training has fallen.

Table 1. Summary Of The Companies Studied

	Shanghai-VW	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
Foreign Partner	VW AG, Germany	General Motors, USA	Delphi Auto System, USA	Daimler-Chrysler, Germany
Initial Registered Capital	19 million US$	50 million US$	N/A	147 million US$
Total Initial Investment	119 million US$	50 million US$	Over 400 million US$ by 2000.	411 million US$
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 of Establishment	1985	1997	Varies from 1995 to 1998	1983
Length of JV Contract	25 years	30 years	Varies from 30 to 50 years	20 years
Location	Shanghai	Shanghai	Various locations around China	Beijing, China
Main Product	VW brand compact vehicles and auto components.	Automotive R&D services, ranging from localization of foreign vehicle design, market research, vehicle styling and design.	Automotive components ranging from steering systems to electric harness.	Cherokee SUV Chinese brand SUV
Annual Capacity	300,000 vehicles	N/A	Total sales of Delphi-China reaches 400 million US$ in 2000.	About 80,000 vehicles

Sources: The data draw from “Summary & Guide of Foreign Enterprises in China Automotive Industry”, published in 1998. Some performance data use 1996 statistics.

Figure 1. Two Types Of Inter-Communal Communication Infrastructure

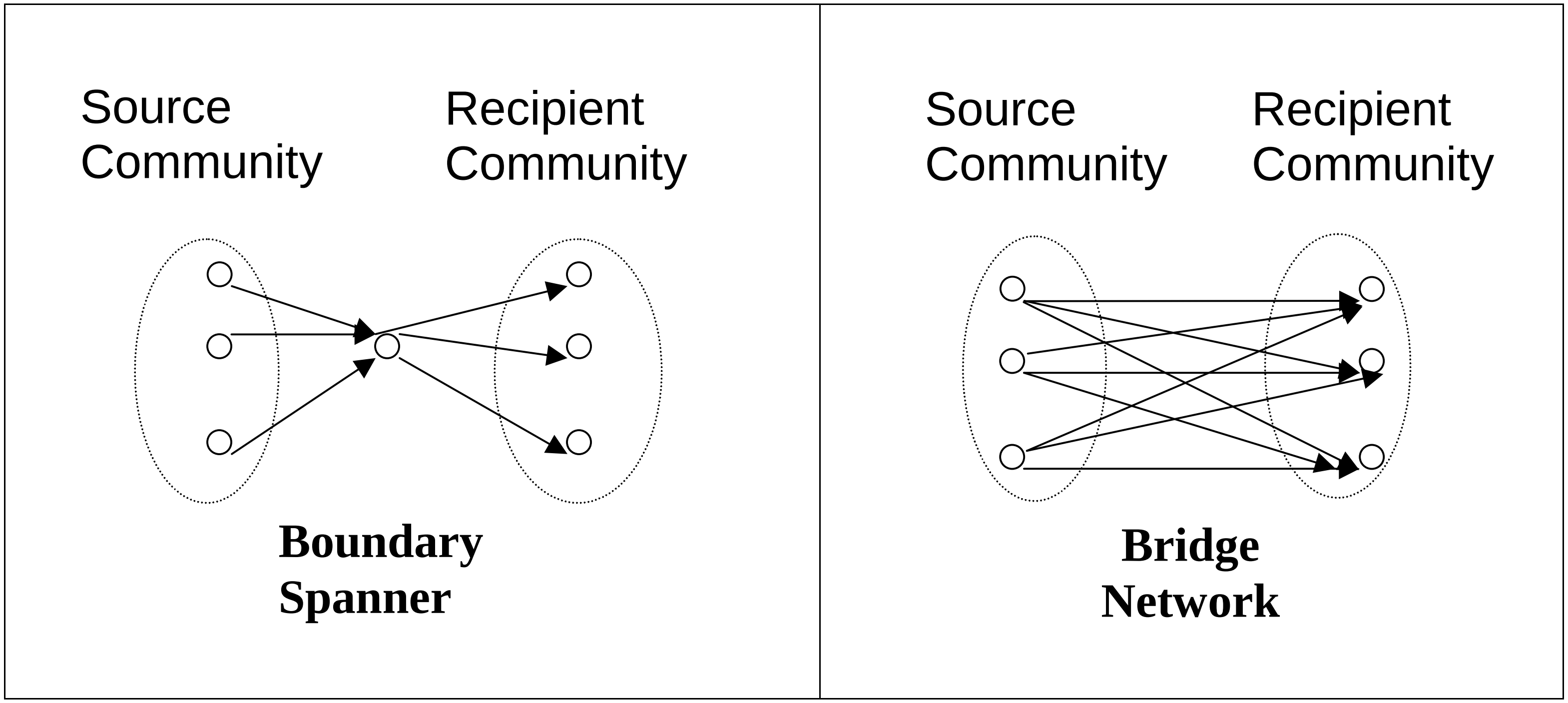

Figure 2. Framework For Comparing Cost Effectiveness Of Collective And Fragmented

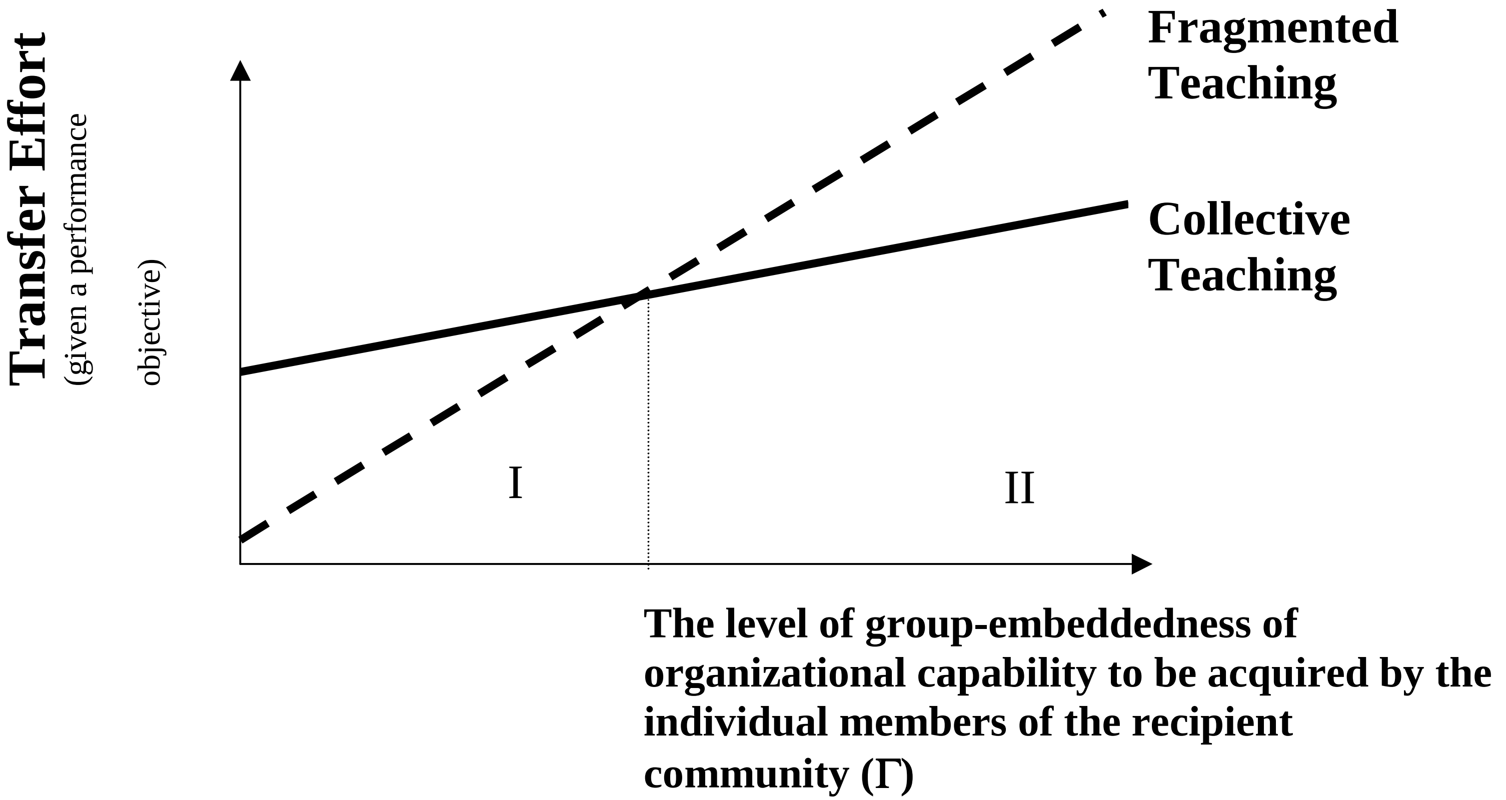

Figure 3. Framework For Comparing Cost Effectiveness Of Collective And Fragmented Learning

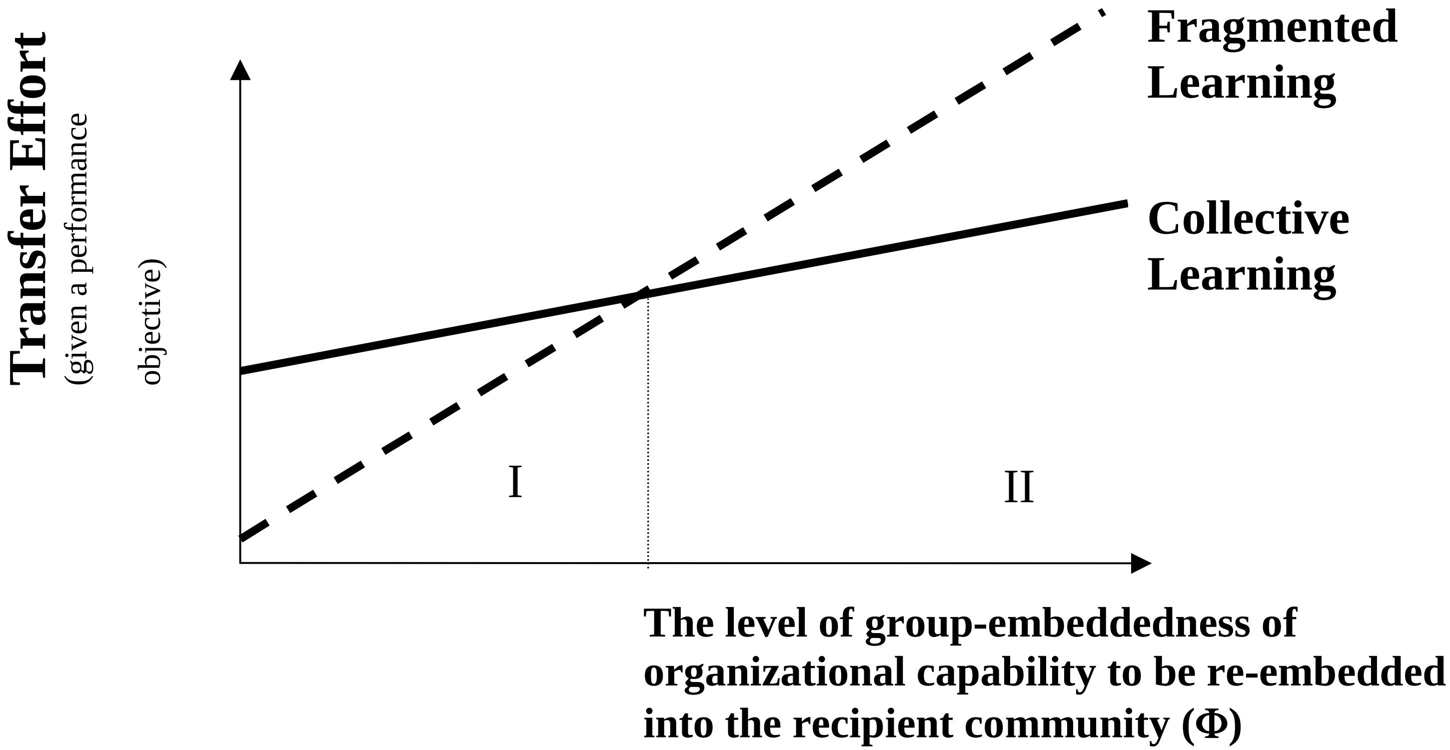

Figure 4. Configurations Of Teaching And Learning Strategies

Learning Strategies		Teaching Strategies: Collective	Teaching Strategies: Fragmented
	Collective	Group on-job training of members of the recipient community at the site of the source community	Lecturing or demonstration by the members of the source community in team-oriented training seminars attended by the members of the recipient community (at either the site of the recipient community or that of the source community) Sending expatriates from the source community to manage or train the members of the recipient community (usually at the site of the recipient community)
	Fragmented	Individual on-job training of the members of the recipient community at the site of the source community	Lecturing or demonstration by the members of the source community in individual-oriented training seminars attended by the members of the recipient community One-on-one apprenticeship between a member from the source community and a member from the recipient community (at either the site of the recipient community or that of the source community)

DAVIDSON INSTITUTE WORKING PAPER SERIES - Most Recent Papers

The entire Working Paper Series may be downloaded free of charge at: www.wdi.bus.umich.edu

CURRENT AS OF 1/17/02

Publication	Authors	Date
No. 420 Transferring Collective Knowledge: Collective and Fragmented Teaching and Learning in the Chinese Auto Industry	Jane Zhou, Jaideep Anand, and Will Mitchell	Dec. 2001
No. 419: Liberalization, Corporate Governance, and the Performance of Newly Privatized Firms	Narjess Boubakri, Jean-Claude Cosset, and Omrane Guedhami	Dec. 2001
No. 418: The European Data Privacy Directive and International Relations	Steven R. Salbu	Dec. 2001
No. 417: Capital Markets and Capital Allocation: Implications for Economies in Transition	Artyom Durnev, Randall Morck, and Bernard Yeung	Dec. 2001
No. 416 Forthcoming in: *The Journal of Economic Perspectives*, "Data Watch. Research Data from Transition Economies," 16(2) Feb. 2002.	Randall K. Filer and Jan Hanousek	Dec. 2001
No. 415 Forthcoming in: *The Journal of Economic Perspectives*, "Transition Economies: Performance and Challenges," 16(2) Feb. 2002.	Jan Svejnar	Dec. 2001
No. 414 Forthcoming in: *The Journal of Economic Perspectives,* "The Great Divide and Beyond: Financial Architecture in Transition," 16(2) Feb. 2002.	Erik Berglof and Patrick Bolton	Dec. 2001
No. 413 Forthcoming in: *The Journal of Economic Perspectives,* "The Political Economy of Transition," 16(2) Feb. 2002.	Gérard Roland	Dec. 2001
No. 412: The Response of Consumption in Russian Households to Economic Shocks	Steven Stillman	Oct. 2001
No. 411: Mark-ups in Hungarian Corporate Sector	László Halpern and Gábor Kőrösi	Aug. 2001
No. 410: Economic Development, Legality, and the Transplant Effect	Daniel Berkowitz, Katarina Pistor, Jean-Francois Richard	Sept. 2001
No. 409: Development Strategy, Viability, and Economic Convergence	Justin Yifu Lin	Oct. 2001
No. 408: Labor Supply, Informal Economy and Russian Transition	Maxim Bouev	May 2001
No. 407: Corporate Governance in China: Then and Now	Cindy Schipani and Liu Junhai	Nov. 2001
No. 406: Entrepreneurship and Post-Socialist Growth	Daniel Berkowitz and David N. DeJong	Oct. 2001
No. 405 Forthcoming in: *European Economic Review,* “Policy Reform and Growth in Post-Soviet Russia.”	Daniel Berkowitz and David N. DeJong	Oct. 2001
No. 404: Social Policies and Structures: Institutional Frictions and Traps in the Czech Republic after 1989	Jiří Večerník	Nov. 2001
No. 403: Investment, Efficiency, and Credit Rationing: Evidence from Hungarian Panel Data	Mathilde Maurel	Nov. 2001
No. 402: Subduing High Inflation in Romania. How to Better Monetary and Exchange Rate Mechanisms?	Daniel Daianu and Radu Vranceanu	Aug. 2001
No. 401: The Gender Wage Gap in Bulgaria: A Semiparametric Estimation of Discrimination	Dean Jolliffe	July 2001
No. 400: Do External Auditors Perform a Corporate Governance Role in Emerging Markets? Evidence from East Asia	Joseph P. H. Fan and T.J. Wong	Oct. 2001
No. 399: Financial Conditions and Investment during the Transition: Evidence from Czech Firms	Lubomír Lízal and Jan Svejnar	Oct. 2001
No. 398: Accessible Pareto-Improvements: Using Market Information to Reform Inefficiencies	Michael Mandler	May 2001
No. 397: The Making of an Integrated National Grain Market in China	Wubiao Zhou	Oct. 2001
No. 396: Corruption and Resource Allocation: Evidence from China	Wei Li	June 2001
No. 395: Government Shareholding and the Value of China's Modern Firms	Lihui Tian	Apr. 2001
No. 394: Labor Hoarding in Russia: Where Does it Come from?	Rouslan Koumakhov and Boris Najman	June 2000