Project-Based Learning , Embedded Learning Contexts and the Management of Knowledge

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Knowledge creation and learning is often a byproduct of project work. Sometimes learning arises from large projects that involve multiple countries and institutions, such as the creation of the tunnel and rail transit connecting England and France; sometimes learning arises from company-centered projects, as in the launch of a new product. Sometimes knowledge arises from work is centered on individual and small group projects, such as the creation of a departmental communications protocol, or a work group database. Whether large or small, projects have the potential for serving as opportunities for individual, community, company and industry learning. However, most often these project-based learning episodes are viewed in isolation. As a result, our understanding of project-based learning and knowledge creation has become balkanized into separate domains of individual, group, company and industry learning, each with its separate research literatures, and each attending exclusively to the learning and knowledge generation, accumulation and diffusion processes specific to each domain (DeFillippi and Ornstein, forthcoming).

The proposed conceptual framework uses the project as a lens to gain a clear, integrated view of workplace learning and knowledge management. The framework makes connections across the multiple parties - individuals, communities, companies and whole industries – investing in the learning process. We believe a better understanding about this set of connections is vital if knowledge and learning in the new economy are to be better understood.

Career –Community-Company- Industry

We have recently developed the model in Figure 1 as a vehicle for exploring the links connecting individual career learning to community, company and industry learning. The model is consistent with ideas about the career as a "repository of knowledge" (Bird, 1996). However, we extend those and related ideas by asserting that the process leading to knowledge accumulation – that is, knowing – involves more than the individual's direct absorption of new skills and expertise. (What follows draws heavily on DeFillippi and Arthur, in press and Arthur, DeFillippi and Lindsay, 2001.)

First, in the case of the individual *career*, we see a person's learning aspirations driven by what we call *knowing-why*, that is by his or her emergent motivation and identity (and incorporating related ideas about interests, personality and life-style) as he or she engages with the world of work (Mirvis and Hall, 1996). Second, we see learning as also influenced by what we call *knowing-whom*, that is by the contacts and reputation (including professional attachments, mentors, and sources of information) on which a person draws in his or her work (Raider and Burt, 1996). Third, we see both knowing-why and knowing-whom combining to stimulate what we call *knowing-how*, namely a person's accumulation of skills and expertise (including what are commonly referred to as formal and informal, and explicit and tacit

knowledge) (Nonaka and Tageuchi, 1995).

The three ways of knowing are persistently interconnected. For example, a person's (knowing-why) identity as, say, an engineer is likely to connect to both the (knowing-whom) professional contacts he or she sustains and the new (knowing-how) experiences he or she accumulates in the engineering field. The interplay among the three ways of knowing will continue as a project unfolds. For example, a new project team member may be recruited for some particular (knowing-how) skill set, but may then engage more broadly through (knowing-why) identification with the overall project purpose, and through (knowing-whom) social interaction with other project members.

This view of career-based knowing embodies a number of assumptions about the process behind individual learning. It emphasizes on-the-job (knowing-how) learning as a central theme in people's work behavior (Senge, 1990). It recognizes the likelihood of people drawing tacit learning out of one another, as the project unfolds (Nonaka, 1994). It acknowledges that people's (knowing-why) motivation to learn will directly influence the learning process (Mirvis and Hall, 1996). It further incorporates interpersonal channels through which learning can occur, spanning people's (knowing-whom) relationships with peers, mentors and other work-related contacts (Hall, 1996).

Second, we see people's unfolding career investments influencing the *community* attachments that they make. Various recent writers have suggested that people voluntarily attach themselves to "communities of practice," which involve closely overlapping (knowing-why) member identities, affirmed by persistent (knowing-whom) social interaction and leading to shared (knowing-how) agendas about the practice of work (Brown and Duguid, 1991; Wenger, 1998). Mirvis (1997) makes a similar case for communities to include "the [knowing-why] emotive experience of feeling close together" and of "living at least some of your [knowing-whom] life with others" in the pursuit of shared (knowing-how) obligations and commitments. In their career behavior people associate themselves with various "pure types" of community, including those centered in a particular industry, occupation, project activity, ideological purpose or company objective to which the project community members subscribe (Parker and Arthur, 2000).

As a project-based learning context, communities of practice engage in joint enterprise and develop a shared repertoire of language, skills and experience (Wenger, 1998). These shared repertoires provide access to tacit knowledge and governing assumptions among community members, which can even endure after formal project-based activities cease (Parker and Arthur, 2000). Companies that promote project-based learning also support the development of communities of reflective practitioners who share a (knowing why) sense of purpose, a (knowing-how) learning infrastructure and exposure to mutual (knowing whom) role models (Ayas and Zeniuk, 2001). A sense of community can also live on in participants' memories and social connections after a project is over, and thereby provide a continuing source of new information, wherever the project members are presently located. These connections and information flows are now made easier through the emergence of the electronic web and the online communities of interest that the web makes possible.

Project based work may arise in geographic communities, as described in the literature on industrial districts and industry clusters. Regional agglomeration of potential project collaborators also makes possible the creation of informal communities of practice (Wenger, 1998) for disseminating knowledge that includes not only technical practices but also the code of conduct and habitus (Bourdieu, 1977) of the particular community of practice. Such community-based shared beliefs and standards of practice facilitate project-based collaboration by reducing the uncertainty surrounding the swift formation of new project teams and organizations (Meyerson, et al, 1996).

Third, it has been suggested that a *company* learns through three unfolding arenas of non-financial capital (Hall, 1992), which we label here as company-based cultural capital, human capital, and social capital respectively (Arthur, Inkson and Pringle, 1999). A company's cultural capital reflects the shared (knowing-why) beliefs and values of its members and their related investment in its mission (Barney, 1986). A company's human capital draws on the body of both tacit and explicit (knowing-how) skills and expertise available to the company (Nonaka and Tageuchi, 1995). A company's social capital reflects the set of supplier, alliance partner, and customer contacts with which the company's members have (knowing-whom) relationships, and which provide complementary capabilities or information (Burt, 1992).

The three forms of company capital, like the three ways of knowing, are also interconnected. For example, a company whose culture makes a virtue out of technological leadership is likely to emphasize the recruitment of human capital in the form of newly-minted engineers from relevant leading universities. These engineers are likely in turn to contribute valuable social capital through their collective presence and their links to their larger professional communities. The building of fresh social capital is likely to strengthen the company's cultural capital, and so on.

The notion of company learning is elusive, but in a general sense it involves a form of collective memory derived from a company's past experiences, and which is stimulated by the shared activities of its present individual members or collaborators (Cohen and Sproull, 1996). Moreover, not all learning can occur in response to pre-ordained objectives, since slavish commitment to any objectives would undermine new learning opportunities. From a learning perspective, project success depends upon the *exploration* of new learning avenues for both the company and its project participants. Exploration emphasizes themes of search, experimentation, discovery and innovation (March 1991). Company learning is enhanced through its absorptive capacity, that is its ability to identify, transfer and utilize knowledge from external sources (Cohen and Levinthal, 1990). It involves a transformative logic that is reflected in the company's further assimilation of individual learning through either internal employee development or external recruitment (Jones and Lichenstein, 2000). Although exploration can have near-term productive effects, its principal purpose is to maximize the long-term enhancement of a company's non-financial capital and core competencies from its existing level.

Companies differ in both their readiness to capture new knowledge, and also in the kind of knowledge they are equipped to accumulate. The existence of established routines is likely to create "competency traps," whereby companies become increasingly skilled at exploiting existing organizational knowledge instead of investing in knowledge exploration (Levitt and March 1988). Accordingly, a company's "absorptive capacity" for new project-based learning is substantially derived from the cultural, human and social capital it has previously accumulated (Cohen and Levinthal, 1990). Project-based learning provides no clear panacea for these difficulties. However, projects do provide particular opportunities to both organize for and experiment in new knowledge-capturing approaches. In extreme examples, companies like the Danish hearing aid specialist Oticon are organizing explicitly according to project arrangements, and without developing the more traditional organizational infrastructure that is widely seen to inhibit learning opportunities (Kao, 1996).

Finally, companies typically participate with one another through their host *industry*, and in doing so engage in "population level learning" with one another (Miner and Mezias, 1996; Robinson and Miner, 1996). This occurs through "an embedded logic of exchange" involving the interplay of cultural, human and social capital whereby companies contribute to and draw learning from one another (Uzzi, 1996). People who are "at the periphery" of their companies have a particular opportunity to engage in inter-company – and therefore industry – learning endeavors (Richter, 1998). Industry learning also occurs through career mobility as a participant company absorbs the knowledge of its newest members (March, 1991). It is increasingly recognized that such mobility, and the self-interested career behavior underlying it, can be vital to the health of industries at large (Powell, 1998), and that learning can accrue to the industry while participant firms come and go (DeFillippi and Arthur, 1998).

Hence, project collaboration within a regional industry community (e.g. Silicon Valley, Route 128, or London's Soho media cluster) is facilitated by the existence of dense networks of cooperative relations among knowledge creating companies and institutions (e.g. universities, government research laboratories). Such cooperation includes not only project collaboration but also knowledge about technological advances within industries and occupations relevant to each company. Some of this external learning is absorbed into companies that recruit workers from within the region. Other times, this external learning is acquired through the process of collaboration with partner companies and institutions (Hendry, Brown and DeFillippi, 2000a, 2000b).

Evidence is now accumulating that forward-looking company extend their effective learning boundaries through the network structures of their host industries (Walker, Kogut and Shan, 1997). This has typically taken the form of partnerships and strategic alliances on a project-by-project basis. However, some companies are now creating more inclusive and enduring forums to promote industry learning. An exemplar is the Nordvest Forum, which was explicitly established to promote accelerated learning in an industry cluster of marine engineering firms. The initiative makes a particular point to promote simultaneous learning at three levels, namely those of participating individuals, companies and of the host industry region (Hanssen-Bauer and Snow, 1998).

Insert Figure 1 around here

Structuration and Strong and Weak Situations

Figure one reflects something of Gidden's ideas on structuration, as redrawn by Barley (1989), that is of people's careers both shaping and being shaped by the institutions they help create. It also captures a central theme in Weick's work on the enactment of careers, namely that "restructuring originates from the bottom up" through "assertion of personality and collective improvisation (that) first strengthens situations and then redraws organizational boundaries" (Weick, 1996, p. 44).

In order to further understand how learning may arise from such dyadic interactions of learning context participants, we have adopted Weick's (1996) distinction between strong and weak situations. A strong situation arises where one learning context dominates another context and imposes its structural character, processes and decision premises. For example, a company may define project learning in terms of a pre-specified set of deliverables which are monitored and measured by the company sponsor and which determine the company sponsor's assessment, recognition and reward of each project team member's learning achievements. Under such a strong situation, project team members tend to define learning according to the criteria established by their company sponsors. Alternately, a company could abdicate setting any learning goals for projects beyond those defined by project team members. In this situation, the project team members have the opportunity to subjectively define project learning according to their own idiosyncratic criteria. Under such a situation, the company provides a weak situation and the project participants are thus free to construct their own learning agendas. Generally, the project participants are not in the position to impose their learning agenda on the company at large. However, were they able to do so, then the project's individual learning context would be the strong situation and the company-learning context would be the weak situation.

In recent work we have illustrated the applicability of Figure 1 by reference to the independent film-making industry (which has persistently outperformed the old studio-centric alternative), the Silicon Valley high technology industry (which appears to rely on enduring community but temporary company attachments) and the New Zealand boat building industry (a highly adaptive industry cluster that earned successive America's Cup victories from a relatively tiny host population and economy) (Arthur, DeFillippi and Lindsay, 2001). All three industries reflect high levels of innovation, and thereby suggest relatively high opportunities for learning and knowledge creation. All three have an underlying project-based approach to industry development.

A further feature of contemporary, innovation-centered industrial life is the emergence of the world wide web. The web now has a pervasive effect on all industries, not just the high technology industry that first spawned it. Some claim that the web and its ability to host virtual connections across buyers, sellers and other stakeholders, has become the primary mechanism for the accumulation of knowledge-based capital (Tapscott, Ticoll, and Lowy, 2000).

Our model suggests that knowledge creation and learning arises from projects, which may be defined as temporary systems for goal-oriented activity and task accomplishment (Lundin and Soderholm, 1995). While the projects that create knowledge and learning are short-lived, our perspective suggests that such projects are embedded in a more durable set of contexts which survive the project and which serve as knowledge and learning repositories. Consistent with structuration theory, our perspective emphasizes the central importance of actors as knowledgeable and purposive in their actions. They are capable of providing a rationale for their project actions through their reflexive monitoring of their of their project-based interactions. Also consistent with structuration theory, we assume that actors may influence the learning contexts for their project-based interactions without fully controlling these contexts. Thus, each learning context is a contested terrain in which the context and actors operating with the context exert reciprocal influence on each other. It is out of such contested, reciprocal interactions that meaning is constructed and learning arises. However, the model in Figure 1 is limited, since it only shows one-way relationships between each of its constituent variables. A more complete representation would address the interdependence between the elements of the model, to which we now turn.

Individual–Company Learning Dynamics

Our model further conceptualizes project-based learning as shaped by tensions and reciprocal interactions between each of the four learning contexts. For example, the most typical and oft studied dyadic learning dynamic concerns the individual project team member and the organizational or company context in which the project arises. What are the respective learning benefits from project work to the individual project participants and what are the learning returns to the sponsoring company? Previous research has documented several alternative patterns of learning benefits between project participants and company sponsors (Arthur, DeFillippi and Jones, 2001).

In some situations, the project's individual participants are the primary beneficiaries of learning new skills, new technologies and new processes for task accomplishment whereas the company sponsor retains little of these learning gains in their subsequent practices and future project work. In other situations, knowledge creation by the project participants is codified into improved practices and organization routines. Company learning benefits may outweigh individual learning in the case of project failures, where the company sponsor gains insight into systemic causes of failure and is able to learn from failure by virtue of a more holistic understanding of the project failure than is accessible to the individual project participants.

Several company-based practices are available to enable both project participants and project sponsors to learn from their project experiences. In particular, the use of "reflective

learning" after a project's completion can help participating managerial and technical personnel to explore and affirm what they learned from the project experience, and leave them better prepared for more challenging projects in the future (Raelin, 2000, Smith, 2001). However, companies may not necessarily provide the time or the opportunity for this kind of reflection to occur, and thereby may short-circuit the company learning opportunity (Keegan and Turner, 2001).

The relative strength of the company versus the individual in defining the learning agenda from project-based work is another facet of the creative dynamic described previously under strong versus weak situations (Weick, 1996). Strong company-defined learning situations typically arise when companies enact highly structured organization learning initiatives in which the design and direction for learning is decidedly top down. Jack Welch's initiatives to speed the rate of learning at General Electric through work-outs and other learning interventions orchestrated at GE's corporate university at Crotonville illustrate a strong company-defined learning situation. At GE, corporate executives are trained in the latest management practices (e.g. demand flow manufacturing, quick service/quick response, or Six Sigma quality) and are expected to use these newly learned tools in their business units. Indeed, company performance evaluations for learning participants and their business units are adjusted to reflect the expected benefits from use of these new tools (Lucier and Torsilieri, 2001). When such company-defined learning situations produce visible success, as has occurred in a number of GE learning interventions, company employees tend to accept the company's definition of their learning agendas.

Weak company defined learning situations arise when learning initiatives originate from the bottom up within subunits of the company and are neither championed nor controlled by top management. An example of a weak company learning situation arose at a major consumer products company where the newly appointed product manager for a surgical instruments unit determined that the unit needed to learn the latest in product development process techniques in order to keep up with industry rivals. Although the unit succeeded in reducing cycle time for product development and reported greater customer satisfaction, the divisional leadership failed to reward the unit's management for its innovative practices and instead re-imposed the standard product development processes employed elsewhere in the division. As a result some of the unit's key staff left the company and found employment elsewhere in the industry, where their experience with fast cycle product development process techniques was more valued than within the very company where their learning project to improve product development had occurred..

In the preceding example, individual learning arose because of the initial bottom up experimentation with new product development techniques. However, the diffusion of lessons learned to other units in the division was actively stymied by a divisional management whose core competencies in product development had become core rigidities (Leonard-Barton, 1995). Hence, learning within the company-individual context was decidedly unidirectional, with individuals of the innovating surgical instruments unit deriving far greater knowledge accumulation and learning from their experience than the larger company (divisional) context in which the experiment arose.

The later case illustrates one of the most common arenas of organization learning interventions, namely how to increase the flow of knowledge and learning from the individual participants to the larger company context, where such knowledge and learning may be put to use on a larger scale and in more diverse applications. The typical instrumentalities to promote such company learning flows are the creation of data bases for storing lessons-learned by project participants. However, major barriers to the success of company knowledge repositories are twofold. First, the significant time demands for performance during fast moving projects often create pressures on individual project participants to focus on those activities directly linked to project deliverables. Quiet reflection and codification of such reflections for data entry into a knowledge repository are often subordinated to the requirements for project productivity (Keegan and Turner, 2001). Secondly, even where lessons learned are recorded in company databases, significant case study evidence exists that company personnel rarely utilize such knowledge repositories for explicit use in future projects (Arthur, DeFillippi and Jones, 2001; Davenport and Prusak, 1998).

Individual –Community Learning Dynamics

A growing body of evidence suggests that individual project work is often embedded in project communities in which project participants develop shared values, common language and joint enterprise (DeFillippi and Arthur, 1998). These communities have an explicit role to play in project-based learning. For example, in the film-making industry, there exists a creative community of actors, directors, and other artistic support personnel who interact with each other both during project work and during the frequent gaps in employment that arise between film projects. These inter-connected individuals have studied together at film school, apprenticed or interned at production companies, or worked together on film projects. During the course of these career-relevant interactions, they have accumulated a common store of knowledge about their craft and about the industry and its requirements for successful project-based participation (Jones and DeFillippi, 1996).

Lessons learned on specific projects frequently are shared informally between members of the film community and specific innovations employed in projects become part of the folklore of the community. Moreover, craft innovations arising during some film projects are celebrated communally at various film festivals and awards ceremonies, where recognition is meted out for specific facets of artistic performance. These well-publicized industry celebrations result in the wide diffusion of knowledge about innovative practices and help disseminate the use of such innovations. Such diffusion arises through the continued employment of award-winning innovators on future film projects and through the imitation of past innovations on future film projects. Nowhere is this better illustrated than in the area of special effects, where each leap in computer-generated effects is rapidly disseminated and incorporated in future film projects.

Implicit in these situations is a reciprocal knowledge sharing dynamic between a project community and its individual members. These forms of community-individual knowledge sharing extend to a wide array of industries and occupations, including most

professions, scientific and technical occupations, and professional and business services. Most of the theorizing on professional communities and associations has focused on the socialization of its membership into a set of occupationally-relevant values (knowing why), practices (knowing how) and the meetings themselves foster the creation of occupationally relevant contacts (knowing-whom). The predominant direction of "community of practice" research similarly suggests a strong community situation influencing the learning dynamics of its membership (Wenger, 1998).

However, there are notable examples where creative and entrepreneurial individuals exert a disproportionate influence on their work-relevant communities, and these examples of strong individual learning dynamics bear noting. Within high technology hardware and software scientific circles, several individuals have launched projects that have either mobilized an extant community or fostered the creation of a supportive community to extend the projects of the originator.

One example of many is that of Carver Mead and his California Institute of Technology collaborators who gave rise to a succession of Silicon Valley semiconductor companies throughout the 1970s and 1980s (Gilder, 1989). A second example is that of Linux Torvalds and his Linux operating system project which has mobilized a global community of thousands of voluntary participants under open software architecture and licensing protocols to freely participate in developing, testing and improving the Linux operating system with each successive cycle of community involvement. The spin-off software and semiconductor companies resulting from Torvalds' and Mead's initiatives offer examples of what has been called the "Silicon Valley Way" (Saxenian, 1994) involving people pursuing their own creativity, attracting a small community of followers, founding a company, and taking a turn at changing the industry. The learning dynamic resulting from creative communities is arguably the same for the geographically-defined creative communities of Silicon Valley as it is for the global and virtual communities of Linux (Tuomi, 2001).

A promising example of theorizing about the role of the creative individuals embedded in a creative community is reflected in Csikzentmihalyi's (1996,1999) work., which contains three important assumptions. First, individual creativity is viewed as arising from a dialectical or interactive process, in response to a set of rules and practices transmitted from an existing domain. To cite Csikzentmihalyi (1999, p 315), "One can be a creative carpenter, cook, composer, chemist or clergyman because the domains of woodworking, gastronomy, music, chemistry and religion exist." Subsequently, the novelty, such as a new gastronomic recipe or chemical compound, is selected for inclusion in the domain. Hence, the creative individual makes a contribution within the current opportunities and constraints of their creative community and as a consequence, such creative individuals help to either redefine or reinforce the prevailing learning agenda and knowledge scope and practices of their community.

A second assumption from Csikzentmihalyi is that creative individuals introduce change through their job performance. In evolutionary terms, this involves an individual "producing a variation which is selected by the environment (Csikzentmihalyi, 1999, p. 316) through job behavior. This concurs with recent observations about "idiosyncratic jobs" (Miner, 1990), which in turn influence other jobs in the same domain. Linus Torvalds created the Linux operating

system project and also created the role of the Linux community organizer. The success of his project and role as community organizer results in a Linux domain that supported first a half dozen, then hundreds, then thousands of people worldwide in jobs (some voluntary and non-profit and others quite profitable) that became embedded in the Linux community project.

A third assumption from Csikzentmihalyi is that creative people fundamentally change the context or domain which originally nurtured their creative practices. The change is effected through "gatekeepers," for example "the teachers, critics, journal editors, museum creators, agency directors and foundation officers" (Csikzentmihalyi, 1999. p. 315) through whom change is introduced. For example, the open software movement that predated Linus Torvalds was impacted by his Linux operating system project (Wayner, 2000). In the space of a few years, the system appears to have fundamentally transformed established practice in the open software domain. This transformation has brought about new commercial software activities to mediate between the emergent Linux community and the information technology marketplace.

Company-Community Learning Dynamics

Companies themselves may be viewed as actors embedded within a community context of other actors. In our perspective we distinguish between the project community of individual actors who have a stake in a company's learning agenda and the industry community (or cluster) of other companies and organizations, which we will treat separately as Company-Industry Learning Dynamics in the next section of this paper.

Typically, research on organization learning and knowledge management has characterized the external community of individual stakeholders as a weak situation and the company as the strong situation in the learning dynamics of the two contexts.
Hence, companies may recruit for specific types of knowledge and experience within the external labor market and thus define for the community of prospective employees the relevant knowledge skills and experiences required. Similarly, companies may choose to alter their future direction by the hiring of a CEO with dissimilar experience and skills and with the expectation that a CEO or top management team with divergent backgrounds from their predecessors will impart new thinking and new learning within the company. However, even in these circumstances, the assumption is that the company (or its board of directors in concert with an executive search firm) is searching for some greater variation that it has pre-specified and then selecting the most attractive candidate from a market place of available skills, experience and perspectives. Hence it is the company that is defining the requisite diversity or variation sought from the community of potential executives for the company.

As imperative as these company initiatives are in defining the future trajectory of the company, it is also the case that communities of stakeholders may exert a profound influence on the learning agendas of their embedded companies. A striking example of this is offered from the Linux-based operating system industry. Although the copyright restrictions of the General Licensing Agreement prohibit companies from developing proprietary Linux software, there is a growing industry of Linux companies that provide Linux shrink ware and related application services. These companies depend upon the Linux community of software

developers for the latest versions of their operating system and the Linux community exerts considerable influence upon the R and D and applications development projects undertaken by these companies.

A prime example of a strong community embedded situation for company learning may be found at Red Hat Software, a distributor of shrink-wrapped versions of Linux and a publisher of Linux books, open source tools and technical support. For example, Red Hat funds development work by Linux software community "inner circle" member, Alan Cox, who does not directly work for Red Hat. This form of Linux development funding is viewed as an invaluable mechanism for Linux commercial companies to support the continuation of the Linux community phenomenon.

Moreover, Red Hat provides an attractive employment setting for Linux community members that sustains their involvement in Linux-related development. Red Hat employment also provide tangible career benefits from the availability of free Linux code from other developers, and intangible benefits of loyalty and credibility from computer system manufacturers, corporate customers, distributors and more (Tapscott, Ticoll, and Lowy, 2000, p. 123).

According to Red Hat's Chief Operating Officer, Tim Buckley:

"*The last thing we want to do is start getting isolated from the (Linux) community, which we are accused of a bit, but only because we are getting bigger and have a reputation…(It) makes us want to double our efforts. We…give everything back to the community. (We) have three or four of the top (Linux) kernel developers on our payroll and they're not developing Red Hat stuff - that's just another sign that we're trying to make sure the community and the kernel development remains solid."* (MacCormack and Herman, 1999, page 11).

More broadly, the case can be made that the Linux community context has largely created the company and industry context. The Linux phenomenon has created a wave of company start-ups that have utilized the free, non-proprietary Linux system to develop applications and services with a commercial value. In 1999 alone, Linux-based initial public offerings achieved market capitalizations of over one hundred billion dollars (Paulson, 2000). These observations pre-date the subsequent downslide in market valuations of Red Hat and other "dot.coms." However, the overall evidence remains impressive that increasing numbers of established and start-up companies are using Linux applications (Economist, 2001).

The entrepreneurs within these companies include both Linux development contributors and independent software entrepreneurs exploiting the market opportunities that the Linux programmer community has made available. Linux insiders report that the major Linux-based commercial businesses have offered pre-IPO access to long-time members of the Linux developer and commercial user communities. Registered Red Hat, VA Linux, and Andover.Net customers as well as Linux code developers allegedly received notification of pending IPOs and an opportunity to participate early in the public offerings for Linux-based distribution companies (Logue, 2000). This practice is a prime example of the open source Linux community's commitment to their members.

In summary, the extended example of Linux suggests that global, web-connected communities of creative people may constitute the strong community-embedded context in which companies and industries are created and in which their learning agendas unfold. Similar examples of strong community-embedded learning contexts are likely to arise where-ever companies are dependent upon the idiosyncratic creative contributions of individuals whose project work is modular and may be disaggregated from specific company contexts. Thus, strong community-embedded learning contexts are likely to be found in the new media (e.g. role playing and virtual reality internet-based games), in highly advanced software, and in designer-label fashion and celebrity-dominated entertainment industries.

The Company-Industry Learning Dynamic

Knowledge creation and knowledge sharing between companies and knowledge supportive institutions within an industry or set of related industries is an arena of increasing attention by learning and knowledge management scholars. This research and theorizing may be examined in terms of several distinct streams, which we briefly illustrate below before concluding with some general observations on the learning dynamics represented by these streams.

One stream examines how project-based learning arises within co-located geographic locales, variously described as industry clusters (Porter, 1990) or geographic clusters (Maskell, 2001). A basic assumption of this scholarship is that project-work is facilitated by the spatial proximity of multiple company and organizational contributors of complementary knowledge and resources and that such co location of organizational resources economizes on transaction costs related to search, selection and monitoring. Moreover, this stream of theorizing suggests that geographic proximity favors face-to-face interactions among representatives of collaborating companies and thus makes possible continuous monitoring of project work and dissemination of project lessons learned among participants (Grabner, 2001). Advocates for the spatial embeddedness of project work within industry specific clusters of cooperating firms argue that those locales that foster such cooperative project collaborations are likely to benefit in terms of higher rates of economic growth, levels of employment and attraction of multinational firms wishing to directly invest in such "hot spots" of industry relevant innovation (Best, 2002; Keeble, 2000).

From a knowledge management perspective, scholars studying industry or geographic clusters suggest that tacit knowledge is geographically embedded in localities and interactive learning arises in geographic proximity (Solvell and Zander, 1998). One of the particular challenges posed by project organizations is that the completion of a project typically results in the dissolution of the project organization. Project organizations or project-organized alliances may create new knowledge, but how is such knowledge stored for future use? Moreover, how is such knowledge accumulated so that future project organizations may avoid having to relearn the lessons of previous project organizations? What are the repositories for project-based knowledge

and how do these capture and transfer knowledge across projects and across project organizations separated by time and space?

Several differing answers are currently suggested by current theory and research on industry and cluster embedded learning. One perspective suggests that industries evolve cognitive and normative institutional logics (Thorton and Ocasio, 1999) or industry recipes (Spender, 1989) that preserve the most valuable lessons learned from project work within an industry as part of the folklore or wisdom of the industry. Such explanations seem similar to the community-of-practice arguments employed previously to explain community embedded learning. Such explanations suggest that industry knowledge is socially embedded in the cognitive communities of industry participants (Porac et. al, 1989).

Structuration theory (Giddens, 1984) examines the processes by which actors reproduce and transform social practices across time and space. Actors are seen as knowledgeable and purposive in their actions However, actors are also seen as constrained by institutional rules and processes to engage in actions which largely reproduce the structural context in which their actions arise. From a project learning perspective, temporary project organizations or project alliances are embedded within the institutional rules and processes that govern relations among the more durable institutions and organizations that constitute a project network (Windeler and Sydow, 2001).

The project network thus comprises a system or more or less enduring social relationships and institutional rules. The project network connects the project-based enterprise (DeFillippi and Arthur, 1998) to the firms that participate in the project as well as to the industry and institutionally based environments in which these firms are embedded (Sydow and Staber, 2002). Project networks thus rely heavily on institutions, which set professional standards and rules and require certification and qualification of resources (human and non-human) to be employed in project work. It is the operation of these institutional and industry rules and practices that govern and constrain the inter-organizational practices of knowledge creation and diffusion among organizational participants in project networks (Windeler and Sydow, 2001).

However, project networks need not be limited to spatially localized industry clusters. Indeed, both theoretic arguments and empirical evidence suggests that formal collaboration for new knowledge development can take place among globally dispersed project participants (Keeble et al, 1999; Huggins, 1997). These global networks for project collaboration do not necessarily argue against the existence and operation of locally embedded project networks. Instead, the presence of global networks of project collaboration suggests that localized industry clusters may often serve as critical knowledge generating and knowledge distribution nodes for more global networks of knowledge (Amin and Thrift, 1992)

Research into industry clusters suggests that firms within clusters are more apt to have significant linkages with firms outside their cluster than with firms inside their cluster. For example, in the Cambridge UK technology cluster, Garnesy and Cannon-Brokes (1993) report that many Cambridge managers see themselves as networking more with firms abroad in

supplier and customer relationships than with firms in the Cambridge area. This perspective supports the view of Amin and Thrift (1993) who portray industry clusters as 'Neo-Marshallian' nodes in a global network.

In examining the local versus non-local linkages between industry cluster firms, Storper (1995) distinguishes between traded and untraded interdependencies. In his view, inter-cluster relations are the primary locale for traded interdependencies, namely the buying and selling of specific technological, material and human capital assets. Storper suggests that geographically concentrated industry clusters are the more likely site for untraded interdependencies, for example, the exchange of tacit knowledge among local industry participants.

However, this perspective has not been substantiated empirically, and there exists alternative venues for nontraded interdependencies to arise outside the geographically concentrated cluster. Industry and professional associations are trans-cluster agents for convening specialists from multiple geographic clusters. Such professional society meetings and the activities and member communications (via journals, newsletters and electronic bulletin boards, and virtual communities) that occur between meetings provide an alternative venue for communities of practice to arise that span the geographic boundaries of industry clusters. Finally, the increasing importance of multi-firm collaborative ventures is giving rise to virtual project teams that link project participants from separate geographic locales through the use of advanced information technology (Quinn, Baruch, and Zien, 1997).

Conclusions and Implications

The preceding discussion has examined how project-based learning and knowledge management arise in a multiplicity of individual, community, company and industry-based institutional arenas whose inter-relations create learning dynamics that define the embedded contexts for project learning. We examined these learning dynamics in terms of tensions arising between inter-related pairs of learning contexts and illustrated the pattern of strong or weak situation definition arising from the relative dominance of one context in relation to the other in defining the embedded learning agenda. We also noted the tendency of learning and knowledge management scholars to typically focus on one or more learning arena to the relative neglect of its counterpart.

As noted earlier, our original Figure 1 did not take account of the interdependencies that this paper subsequently examined. Our further discussion has affirmed that knowledge flows operate within a complex system of interdependent, reciprocal interactions (Cillier, 1998, 2001). These knowledge flows are bidirectional, and occur between all the four nodes of figure one. Because of this recursive property, each node is both a cause and consequence of knowledge flows arising within the diamond (Giddens, 1984). We therefore offer an alternative model, represented in Figure 2, to capture this full set of interdependencies.

(Insert Figure 2 about here)

In summary, we conclude that the learning and knowledge management literatures suffers from the balkanization and fragmentation of it domain into only loosely coupled arenas for study. In part, such fragmentation is a requirement for deeply probing and analyzing the intricacies of project based learning and knowledge management. At the same time, analytic decomposition of project-based learning into separate levels of analysis and study deprives both scholars and practitioners the opportunity to make holistic interpretations of the inter-relations between individual, community, company and industry learning.

We humbly suggest that more scholars seek to find the connections between these multiple levels and arenas for learning. We believe that such an investment will enrich theorizing by explicating the relationships between more macro and more micro processes of learning. Such efforts may require the use of multi-level emergent theories such as complexity theory and its component concepts, such as coevolution and self-organization (Cilliers, 1998). McKelvey's important contribution to co evolutionary theory distinguishes between organization-level (micro-coevolution) and environmental (macro-coevolution) evolution (McKelvey, 1997). He contends that micro-coevolutionary adaptation occurs within the context of macro-coevolutionary competitive pressure. The application of such coevolutionary thinking to the examination of inter-related project based learning is beyond the scope of the present paper but initial attempts to develop such multi-level theorizing are now afoot and empirical research in support of such frameworks of analysis will hopefully follow (Arthur, DeFillippi and Lindsay, 2001; DeFillippi and Arthur, forthcoming)

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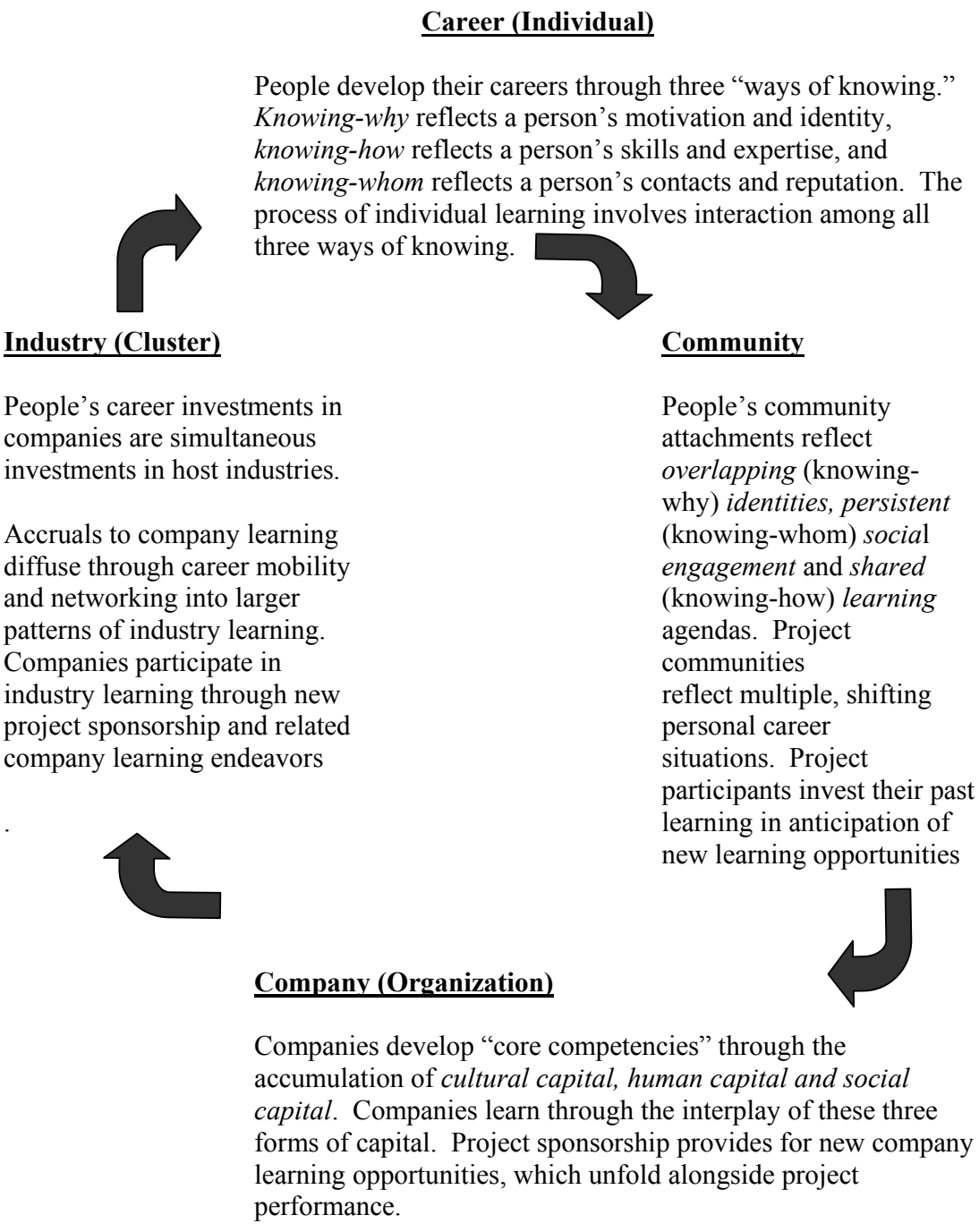

Figure 1: The Links among Individual (Career), Community, Organizational (Company) and Industry (Cluster) Learning

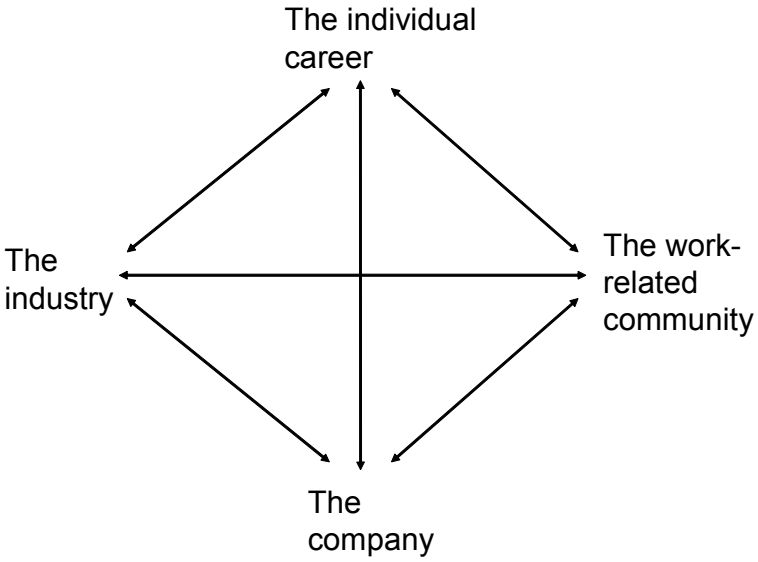

Figure 2: Interdependencies among individual, community, company and industry learning