Learning at the Biotechnology Interface; an Activity Theory Perspective

Ms Anna Stephens

University of Queensland

astephens@business.uq.edu.au

ABSTRACT

This paper seeks to extend our understanding of learning in biotechnology clusters. The development of the biotechnology industry is recognised to be a geographically-concentrated phenomenon. A widely-held explanation for this clustering is posited to be the enhanced learning that occurs in such agglomerations. In the existing literature, however, there is a dearth of studies that examine these processes. We begin to address this gap.

Drawing on activity theory, we develop a framework for the analysis of learning in biotechnology clusters. We argue that this approach enables the study of these processes within context, and allows for more nuanced conceptualisations of learning and knowledge in clusters. We also demonstrate how this framework could be applied to examine a specific mechanism of learning in clusters, collaboration.

Keywords: biotechnology cluster, learning, knowledge, activity theory.

INTRODUCTION

This paper explores the learning processes occurring within industrial clusters. The key contribution we make is the conceptualisation and theoretical development of an applied framework for the study of this phenomenon in biotechnology clusters. We also demonstrate how this framework may be deployed to understand the processes, mechanisms and contextual issues that underpin learning in biotechnology clusters.

Cluster learning processes are defined as the cumulative learning processes that take place over time among a community of firms in a locality (MacKinnon, Cumbers & Chapman, 2002) These processes are widely theorised to be a fundamental reason for the existence of industrial clusters and an important source of competitive advantage for their constituents (Asheim, 1996; Maskell, 2001; Pinch et al., 2003). Despite their perceived significance in cluster emergence and outcomes, the learning dynamics of clusters are not well understood. Current theories considering the nature and mechanisms of learning in clusters are ambiguous and often conflicting, and have been criticised for lacking a solid basis in empirical inquiry (Hudson, 1999; Martin and Sunley, 2003; MacKinnon, Cumbers and Chapman, 2002). A particularly noteworthy issue, which is further explored in this paper, is that key assertions about the nature of cluster learning processes and how they may impact on cluster constituents remain unexamined at the level of the firm. Addressing this gap in current understanding is the focus of this paper.

The context for our exploration of cluster learning processes is the biotechnology industry. Globally, the biotechnology industry has demonstrated a tendency to cluster in particular regions or locations. Furthermore, issues concerning knowledge and learning are recognised as central in the success and sustainability of biotechnology firms (Brink et al., 2004). According to current arguments within the literature, locating in a cluster may enable firms to realise higher rates of innovation, increased entrepreneurial activity and increased productivity due to the advantages afforded by localised learning processes (Feldman, 2003). Thus, the research question posed in this paper is: **What is the nature of the learning processes occurring within a biotechnology cluster?**

SIGNIFICANCE & RATIONALE

The proposed research can build theory to explain how the learning processes of a biotechnology cluster impact upon knowing in constituent biotechnology firms. The three core themes for theory building in this paper—clusters, knowledge and learning, and biotechnology—have in recent years emerged as areas of considerable research activity.

Learning and its significance for firms, regions and nations has received much attention due to the emergence of the 'learning economy'. The learning economy signifies a society in which the capability to learn is critical to economic development. In such an economy, knowledge is highlighted as the most strategic resource and learning the most important process (Lundvall, 1994). Of central concern to firms, region and nations then, is the understanding and promotion of learning processes central to economic success.

Associated with the rise of the 'learning economy' has been an increased focus on clusters as drivers of competitiveness and economic development. The cluster concept, popularised by influential authors such as Michael Porter (Porter, 1990), has captured the attention of governments, regional development practitioners, and academics alike (Martin & Sunley, 2003). Despite the concept's popularity and widespread application, however, many important theoretical and practical issues remain. In particular, a number of commentators argue that the application of cluster-based economic development policy has accelerated ahead of conceptual development and empirical testing in cluster research (Martin & Sunley, 2003; Benneworth et al., 2003). Given the copious amounts of funding and effort placed in clustering initiatives globally, it is clear that further research is urgently required to address cluster-based economic development issues.

The final point here concerns the reasoning behind selecting biotechnology as a) the context in which these issues are explored, and b) an area worthy of research. The rationale for this is three-fold. Firstly, as an industry, biotechnology is believed to hold great potential to contribute to the economic development of regions and nations (Brink et al., 2004). Secondly, as a technology, biotechnology is expected to lead to revolutionary advancements in areas ranging from human health to agriculture and environmental remediation (Bartholomew, 1997). Improving our understanding of the firm and regional environments in which the commercial exploitation of these technologies can be encouraged and accelerated is certainly worth the attention of social scientists. Finally, the biotechnology industry is a highly appropriate context for this research, as the learning claims espoused in the literature are held to be particularly pertinent for clusters of knowledge-intensive industries (Feldman, 2003).

LITERATURE REVIEW

In the following brief review of the economic geography field, we outline a number of central themes and key gaps in this literature that relate to biotechnology clusters, learning and knowledge. In particular, we highlight the need for more process-focused research on clusters, and draw attention to the emerging and contested nature of current theories about knowledge and learning. In order to advance our understandings of these concepts, we then turn to organisational learning literature, where a comparatively greater level of theoretical development is evident. Here we explore the applicability of activity theory for the understanding of learning and 'knowing' in biotechnology clusters.

Industrial Clusters & Biotechnology

We adopt an initial understanding of an industrial cluster as a geographically confined, over-proportional agglomeration of firms competing in the same industry, or related industries, and of supporting institutions (Lechner & Dowling, 1999).

Presently, there is much conceptual and empirical confusion about the definition and nature of clusters (Martin & Sunley, 2003; Benneworth et al., 2003). It is clear from existing research that clusters may exist in a number of different forms and display different attributes and processes (e.g. Markusen, 1996; Gordon & McCann, 2000). A useful synthesis of this literature is a cluster analytical framework developed by Pickernell et al. (2006). This framework distinguishes eight 'ideal' types of clusters according to structures, attributes and processes - see Table 1. Further to this, the extant research also suggests that the structures, processes and attributes of a cluster are influenced by the industrial, regional and national context in which it is embedded (Wolfe & Gertler, 2004; Bartholomew, 1999), as well as the stage of cluster development (Bresnahan, Gambardella, & Saxenian, 2001; Pouder & St. John, 1996). These issues must thus be considered in the study of clusters.

Empirical cluster research has traditionally placed greater emphasis on exploring cluster structures and components, to the neglect of cluster processes. To illustrate this point, previous studies of biotechnology agglomerations have tended to primarily concentrate on identifying factors important in cluster emergence and development. Examples of such factors include a strong science base, the presence of entrepreneurial biotechnology start-ups and spin-offs, a favourable business, legal and regulatory environment, the presence of a pharmaceutical industrial base, and the plentiful availability of physical, financial and human capital (Prevezer, 1995; Prevezer, 2001; Walcott, 2004; Chiesa & Chiaroni, 2005). By contrast, important processes occurring within biotechnology clusters—such as learning—are poorly understood. The lack of process-focused research is a thus significant gap in the literature on clusters.

Table 1: Clusters and Networks Classification Framework

Description	**Structures**	**Purpose**	**Firm Focus**	**Firm Mode**	**Network Mode**	**Management focus**	**Learning Processes**
Cluster Type	**Structure**	**Returns**	**Participant Goals**	**Participant conduct**	**Participant basis**	**Network System Management**	**Type of Learning**
1 – Industrial Complex	formal, Vertical, Transactional	Cost	Individual survival	control	transactions	start – creating	Doing things better
2- Hub and Spoke	formal, Vertical, Relational	cost / knowledge	Collective survival	collective action	cognitive trust	survive-connecting	Doing things better / doing things differently
3 Italianate District	informal, vertical, relational	cost / knowledge	collective / wider survival	Collective action / co-operative learning	cognitive trust / teamwork	survive-connecting / sustain / developing	Doing things better / doing things differently/doing different things
4 Marshallian	informal, vertical, agglomerational	Cost	individual / collective survival	Control / co-operative learning	transactions / cognitive trust	start – creating / sustain-developing	Doing things better
5 Urban hierarchy	informal, horizontal, agglomerational	Cost	Individual survival	control	cognitive trust	start – creating	Doing things better
6 Social Network	informal horizontal, relational	Knowledge	Wider survival	co-operative learning	teamwork	sustain-developing	Doing things differently/doing different things
7 Virtual Organisation	formal, horizontal, relational	Knowledge	Collective survival	Collective action	cognitive trust	survive-connecting	Doing things better / doing things differently/doing different things
8 Satellite Industrial Platform	formal, horizontal, transactional	Cost	Individual survival	control	transactions	start – creating	Doing things better

Source: Pickernell et al. (2006)

Learning & Knowledge

Learning is a rather ambiguous concept in economic geography. In terms of a basic conceptual definition, regional collective learning refers to cumulative learning processes that take place over time among a community of firms in a locality. These learning processes require a degree of continuity and stability in inter-firm relations that is likely to be facilitated by spatial proximity (MacKinnon, Cumbers and Chapman, 2002). Further to this, Asheim (1996) also suggests that such processes must be systematically developed and supported at the intra-firm, the inter-firm and the district or regional level. Table 2 presents a brief summary of current thoughts on the types and mechanisms of learning in clusters, as well as the contextual issues that influence these processes.

Table 2: Learning & Knowledge in Clusters – Processes, Mechanisms, and Contextual Issues

Element	**Description**
Learning Processes	Pickernell et al (2006) defined three basic types of learning to occur in clusters: o Doing things better (normally related to a focus on cost) o Doing things differently (focused more knowledge) o Doing different things (focused more on knowledge)
Mechanisms	Keeble and Wilkinson (1999) propose that the main mechanisms for knowledge transmission and learning in clusters include: o Inter-relationships between suppliers and customers and suppliers and the makers and users of capital equipment o Formal and informal collaborative links between firms in particular sectors o Inter-firm mobility of workers in localised markets for high skill o The spin-off of new firms from existing firms, universities and public sector research laboratories. These observations are supported by other commentators (eg. Lawson & Lorenz, 1999; Malmberg, 2003).
Contextual Issues	Keeble and Wilkinson, 1999: o highlight cultural, institutional and geographical factors, often in combination. Coenen, Moodyson and Asheim (2004): o proposes that the knowledge base of the cluster (ie synthetic vs analytic) influences spatial dimensions of learning (eg relative importance of global/local flows) Pinch *et al* (2003): o suggests that it is not so much geographical proximity that facilitates knowledge exchange but communality in terms of norms, values and practices embedded in a community.

A central theme evident in this literature is the relationship between knowledge, learning and location. A basic assumption underpinning work in this area holds that type and nature of knowledge dictates the spatial dimensions in which learning is likely to occur. Table 3 (below) captures this prevailing perception.

Table 3: Relationship between Knowledge Type & Spatial Character

Knowledge Type	Spatial Character	Implication
Tacit	Learning/transfer best accomplished over short distances	Local knowledge flows
Explicit	Learning/transfer can occur over long and short distances	Local and global knowledge flows

Source: Developed for the research.

Linked to this perception is the dominant theory that it is local flows of tacit knowledge that largely explains the enhanced learning of firms locating in clusters (Feldman, 2000; Lawson & Lorenz, 1999).

Contemporary developments have however challenged this explicit/global, tacit/local dichotomy (e.g. Gertler & Levitte, 2004; Bathelt, Malmberg, & Maskell, 2004; Coenen, Moodyson & Asheim, 2004). These dissenting arguments suggest that the distinctions between different forms of knowledge are less clear cut and more fluid than binary divisions such as formal and informal, codified and tacit. Furthermore, it may be too simplistic to claim that a given form of knowledge is inevitably linked to one form of geographical socio-economic organisation or any one scale of social relationships (Martin & Sunley, 2003).

A final point here relates to the perceived failure of the regional learning literature to adequately ground its arguments in empirical enquiry (MacKinnon, Cumbers and Chapman, 2002). There are examples of empirical work seeking to address these concerns (e.g. Coenen, Moodyson & Asheim, 2004; Dahlander & McKelvey, 2005), but these studies tend to examine only the more tangible mechanisms of learning (e.g. formal collaboration as evidenced by co-publication or patenting) and mechanisms such as informal social networks and the local labour market are relatively unexplored. It is our contention that current empirical approaches tend to study learning divorced from the context in which it occurs, and also largely ignore the social nature of the learning processes. Overcoming these issues are important objectives for future research in this area. In the following section we explore activity theory as an approach potentially useful in accomplishing this. Specifically, we put develop a case that activity theory can be used to inform analytical framework that contextualises learning and captures the social nature of the process. In doing so, it is suggested that an activity theory framework can be used to answer the research question we posed earlier in this paper.

Activity Theory

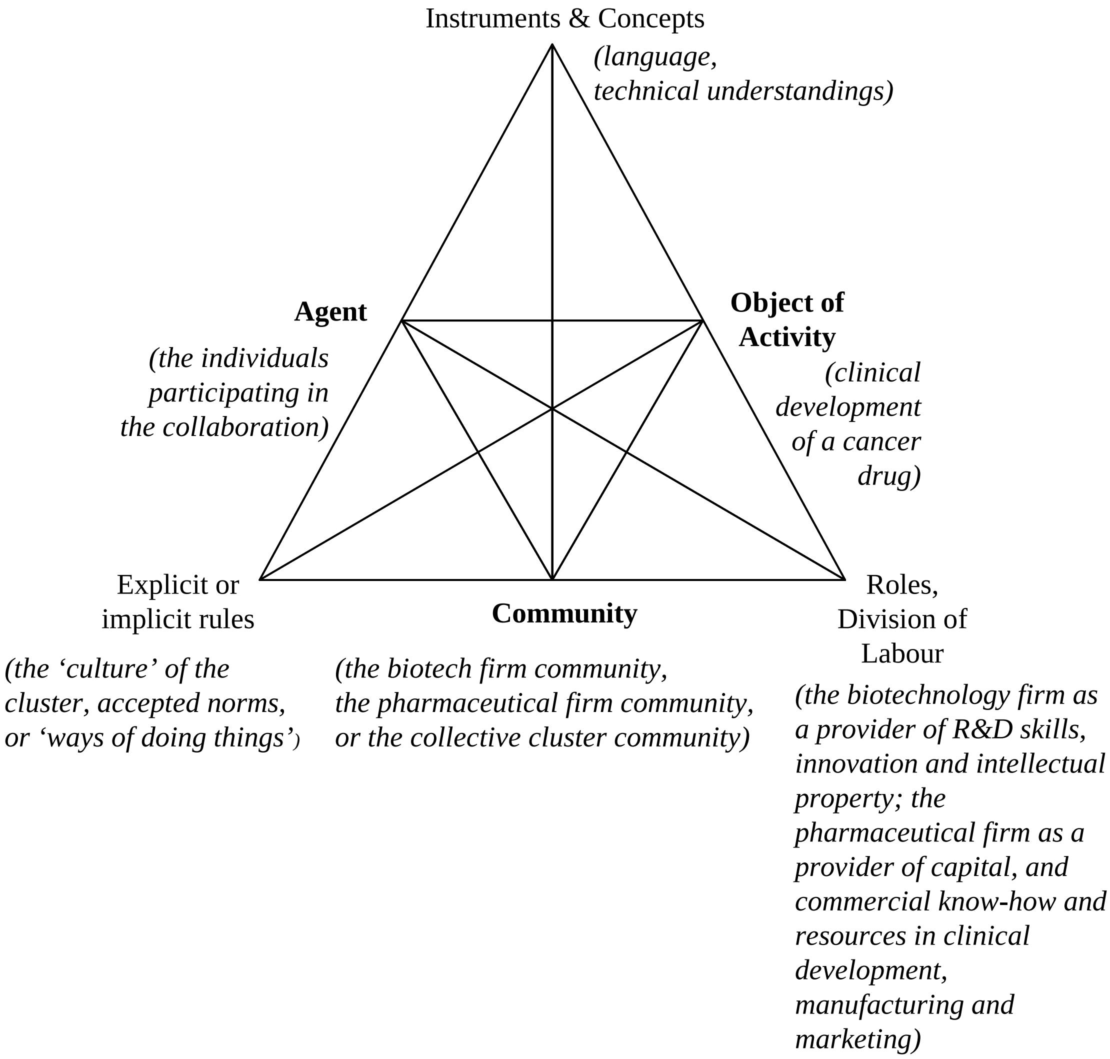
The organisational learning literature holds many insights potentially valuable in advancing cluster research. As discussed, we argue here that organisational activity theory is useful as a theoretical framework for exploring learning and knowledge in clusters. In describing this framework, the seminal works of Blackler (1993; 1995) and Engestrom (1987) on activity theory are heavily drawn upon.

Activity theory has it roots in the idea of the Russian psychologist Vygotsky that it is social experiences that shape consciousness. Organisational studies researchers have adapted Vygotsky's ideas to suggest that processes such learning can only be understood through an appreciation of the culturally provided factors that mediate them. There are a number of elements of activity theory that make it attractive for study of biotechnology clusters.

First, activity theory allows for a more sophisticated appreciation of key concepts such as knowledge and learning. As discussed, the regional learning literature understands knowledge in terms of simplistic (and likely unrealistic) dichotomies, in which knowledge tends to be reified as a 'thing' organisations have and accumulate. In addition to this, knowledge and learning are treated as distinct concepts, although the terms are often used interchangeably. In contrast, activity theory as developed by Blacker (1995) recognises that the distinctions between knowledge and learning are often blurred, and instead adopts the perspective of 'knowing' as something organisations do. Knowing is conceptualised and analysed as a phenomenon which is (a) manifest in systems of language, technology, collaboration and control (i.e. it is mediated); (b) located in time and space and specific to particular contexts (i.e. it is situated); (c) constructed and constantly developed (i.e. it is provisional); (d) purposive and object-oriented (i.e. it is pragmatic); and (e) imbued by power relations (i.e. it is contested).

Secondly, in empirical analysis, activity theory avoids divorcing the study of knowing from the various contexts (e.g. individual, collective and social) in which it takes place. This is accomplished by adopting as the focus of analysis neither individuals nor organisations, but the 'socially-distributed activity system'. Developed by Engestrom (1987; as cited in Blacker, 1995), a general model of a socially distributed activity system, together with a graphic representation of its application in the biotechnology cluster context is presented in Figure One. As Blackler (1995) explains, essential to such systems are the relations between agents, the communities of which they are members, and the conception(s) people have of their activities (the inner triangle of relations in Figure one). Such relations are mediated by a further series of factors, including the language and technologies used by the participants within the system, the implicit and explicit social rules that link them to their broader communities, and the role system and divisions of labour adopted by the community. In the following section, we discuss how activity theory framework can be applied to the study of a particular mechanism of learning in the context of the cluster.

Figure 1: Biotechnology Activity System as an application of the General Model of a Socially-Distributed Activity System



Source: Blackler, 1995

ACTIVITY THEORY AS CONCEPTUAL FRAMEWORK FOR THE STUDY OF FIRM LEARNING IN CLUSTERS – AN EXAMPLE

The research question posed at the beginning of this paper was – What is the nature of learning processes occurring within a biotechnology cluster, and how do they impact on knowing in its constituent firms? To demonstrate in greater detail how activity theory can be applied to explore this issue, we consider below the manner in which a particular mechanism of learning in clusters – collaboration – could be conceptualised and analysed. We take as starting point a hypothetical case study of a formal collaboration between a start-up biotechnology firm and large, multi-national pharmaceutical company. Both of the collaborators are located in a biotechnology cluster. The object of this collaboration is the clinical development of a new drug to treat cancer.

In examination of this case, the biotechnology cluster in which these organisations are located is conceptualised as a socially-distributed activity system - the biotechnology activity system - in which the collaboration occurs as a socially-, historically- and culturally- embedded practice. Central to the biotechnology activity system is the relations between the object of the activity (e.g. the clinical development of a cancer drug), agents (e.g. the individuals participating in the collaboration) and the communities (e.g. the biotech firm community, the pharmaceutical firm community, or the collective cluster community) of which they are part. The object of activity may be considered to be partly known and partly emergent (e.g. while the object of the collaboration is to successfully progress the drug through three stages of clinical trials, the specific activities required to accomplish this are likely to emerge as the process unfolds). In line with Engestrom’s (1987) general model of an activity system, certain elements of the biotechnology activity system mediate the collaborative process. Specifically, the relations between individuals and the object of their activity are mediated by concepts and technologies (e.g. language, technical understandings); the relationships between the community and the overall object of the activity are mediated by its division of labour (e.g. the biotechnology firm as a provider of R&D skills, innovation and intellectual property; the pharmaceutical firm as a provider of capital, and commercial know-how and resources in clinical development, manufacturing and marketing); and the relations between individuals and the communities of which they are part are mediated by implicit and explicit rules and procedures (e.g. the ‘culture’ of the cluster, accepted norms, or ‘ways of doing things’). Together, these elements encompass an interrelated bricolage of material, mental, social and cultural resources for thought and action (Blacker, Crump & McDonald, 2003).

As demonstrated through the above example, an activity theory approach to the study of collaboration in biotechnology clusters draws attention to i) what are people doing, ii) how and with whom are they doing it, and iii) how collective learning may occur. Application of the model allows for 'knowing' in this situation to be explored as a phenomenon that is mediated, situated, provisional, pragmatic and contested. In this way, the use of activity theory to provides the means to move beyond current problematic conceptualisations of learning and knowledge in cluster theory. It is also a novel approach to the study of clusters, and has great potential for generating nuanced and in depth empirical insights into these of vital, yet poorly understood, learning processes. Specifically, based on this review of the literature, six propositions are developed.

Proposition 1: That a biotechnology cluster is a socially-distributed activity system - the biotechnology activity system - in which the collaboration occurs as a socially-, historically- and culturally- embedded practice.

Proposition 2: That the central elements in the biotechnology activity system are the relations between the object of the activity, agents and the communities.

Proposition 3: That the object of activity may be considered to be partly known and partly emergent.

Proposition 4: That the collaborative process between object of activity and agent is mediated by concepts and technologies

Proposition 5: That the relationships between the community and the overall object of the activity are mediated by its division of labour.

Proposition 6: That the relations between individuals and the communities of which they are part are mediated by implicit and explicit rules and procedures.

CONCLUSION

In this paper we have argued that the dynamics of learning in clusters is an important yet relatively unexplored phenomenon in the cluster literature. In particular, the nature of these processes and the way in they may influence firm knowing outcomes is poorly understood. To advance our knowledge of these matters, we have outlined how activity theory can be applied as a conceptual framework for the analysis of learning and knowing in biotechnology clusters. Six propositions are developed to answer the research question. It is intended that research deploying this framework will both challenge and advance current conceptualisations of learning and knowledge in clusters, and lead to richer and more detailed empirical understandings of these important processes. Given thus, such research may also pave the way for more informed cluster-based economic development policy and practice in the future.

References

Asheim, B. (1996). Industrial districts as ‘learning regions’: A condition for prosperity. ***European Planning Studies***. 4(4): 379-401.

Bartholomew, S. (1997). National systems of biotechnology innovation: Complex interdependence in the global system. ***Journal of International Business Studies***. 28(2): 241-266

Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. ***Progress in Human Geography***. 28(1): 31-56.

Benneworth, P, Danson, M., Raines, P., & Whittam, G. (2003). Confusing clusters? Making sense of the cluster approach in theory and practice. ***European Planning Studies***. 11(5): 511-520.

Blacker, F. (1993). Knowledge and the theory of organisations: Organisations as activity systems and the reframing of management. ***Journal of Management Studies***. 30(6): 863-884.

Blackler, F. (1995). Knowledge, knowledge work and organisations: An overview and interpretation. ***Organization Studies***. 16(6): 1021-1046.

Blacker, F., Crump, N., & McDonald, S. (2003). Organising processes in complex activity networks. In Nocolini, D., Gherardi, S., & Yanow, D. (Eds). ***Knowing in Organisations – A Practice-Based Approach***: 126-150. New York: M.E. Sharpe, Inc.

Bresnahan, T., Gambardella, A., & Saxenian, A. (2001) 'Old economy' inputs for 'new economy' outcomes: Cluster formation in the new Silicon Valleys. ***Industrial and Corporate Change***. 10(4): 835-860.

Brink, J., McKelvey, M., & Smith, K. (2004). Conceptualising and measuring modern biotechnology. In McKelvey, M., Rickne, A., & Laage-Hellman, J. (Eds). ***The Economic Dynamics of Modern Biotechnology***: 20-39. Cheltenham: Edward Elgar.

Chiesa, V., & Chiaroni, D. (2005). ***Industrial Clusters in Biotechnology: Driving Forces, Development Processes & Management Practices***. London: Imperial College Press.

Coenen, L., Moodusson, J., & Asheim, B. (2004). Nodes, networks and proximities: On the knowledge dynamics of the Medicon Valley biotech cluster. ***European Planning Studies***. 12(7): 1003-1018.

Dahlander, L., & McKelvey, M. (2005). The occurrence and spatial distribution of collaboration: biotech firms in Gothenburg, Sweden. ***Technology Analysis & Strategic Management***. 17(4): 409-431.

Engestrom, Y. (1987). *Learning by expanding: An activity theoretical approach to developmental research*. Helsinki: Orienta-Konsultit.

Feldman, M. (2000). Location and innovation: the new economics of innovation, spillovers and agglomeration. In Clark, G., Feldman, M.,& Gertler, M. (Eds). ***The Oxford Handbook of Economic Geography***: 373-394. Oxford: Oxford University Press.

Feldman, M. (2003). The locational dynamics of the US biotech industry: Knowledge externalities and the anchor Hypothesis. ***Industry & Innovation***. 10(3): 311-328.

Gertler, M. (2003). Tacit Knowledge and the Economic Geography of Context, or The Undefinable Tacitness of Being (There). ***Journal of Economic Geography*,** 3: 75-99.

Gertler, M. & Levitte, Y. (2004). Local nodes in global networks: The geography of knowledge flows in biotechnology innovation.

Gordon, I., & McCann, P. (2000). Industrial clusters: complexes, agglomeration and/or social networks? ***Urban Studies***. 37(3): 513-532.

Hudson, R. (1999). The learning economy, the learning firm and the learning region: A sympathetic critique of the limits of learning. **European Urban and Regional Studies**. 6(1): 59-72.

Lawson, C. & Lorenz, E. (1999) Collective Learning, tacit knowledge and regional innovative capacity. *Regional Studies*, 33 (4), pp305-319.

Lechner, C & Dowling, M. (1999). The evolution of industrial districts and regional networks: The case of the biotechnology region Munich/Martinsried. ***Journal of Mangagement and Governance***. 3(3/4): 309-338.

Lundvall, B. (1994). The learning economy. ***Journal of Industry Studies***. 1(2): 23-42.

MacKinnon, Cumbers and Chapman, 2002, D., Cumbers, A., & Chapman, K. (2002). Learning, innovation and regional development: A critical appraisal of recent debates. ***Progress in Human Geography***. 26(3): 293-311.

Martin, R., & Sunley, P. (2003). Deconstructing clusters: Chaotic concept or policy panacea? ***Journal of Economic Geography***. 3: 5-35.

Markusen, A. (1996). Sitcky places in slippery spaces: A typology of industrial districts. ***Journal of Economic Geography***. 72(3): 293-314.

Maskell, P. (2001). Towards a Knowledge-based Theory of the Geographical Cluster. ***Industrial and Corporate Change***. 10(4): 921-943.

Maskell, P. & Malmberg, A. (1999). Localised Learning and Industrial Competitiveness. ***Cambridge Journal of Economics***, 23: 167-185.

Pickernell, D., Rowe, P., Brown, K., Keast, R. & Christie, M.J. (2006) A 'Region' that Learns ? Cluster and Network Measurement for Policymaking in Wales : Meeting the Needs of Stakeholders, Paper presented at IRSPM, Glasgow, April 10-13.

Pinch, S., Henry, N., Jenkins, M., & Tallman, S. (2003). From 'industrial districts' to 'knowledge clusters': a model of knowledge dissemination and competitive advantage in industrial agglomerations. ***Journal of Economic Geography***. 3: 373-388.

Prevezer, M. (1995). The dynamics of industrial clustering in biotechnology, ***Small Business Economics***, 9: 255-271.

Prevezer, M. (2001). Ingredients in the early development of the U.S. biotechnology industry. ***Small Business Economics***. 17(1/2): 17-29.

Porter, M. (1990). ***The competitive advantage of nations.*** London: MacMillan.

Pouder, R., & St. John, C. (1996). Hot spots and blind spots: Geographical clusters of firms and innovation. ***Academy of Management Review***. 21(4): 1192-1225.

Walcott, S. (2002). Analysing an innovative environment: San Diego as a bioscience beachhead. ***Economic Development Quarterly***. 16(2): 99-114.

Wolfe, D., & Gertler, M. (2004). Clusters from the inside and out: Local dynamics and global linkages. ***Urban Studies***. 41(5/6): 1071-1093.