

COLLECTIVE COMPETENCE AND WORK PROCESS KNOWLEDGE

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Abstract

Two theoretical constructs for analyzing the competency requirements of modernizing workplaces are collective competence (Boreham, 2000a,b; Boreham 2004b) and work process knowledge (Boreham et al., 2002; Fischer et al., 2004) The term 'modernizing workplace' refers to the re-organization of work by reducing hierarchies, placing more emphasis on teams and delegating much of the authority previously exercised by middle managers and foremen to the teams. Teams constituted in this way assume responsibility for continuous improvement of working practices and adapt themselves responsively to customer/market requirements and the operational needs of other work units (and indeed other organizations). Typically, they are linked to customers and other units/organizations by complex networks of lateral communication, primarily electronic. Teams of this kind need to be competent collectively. 'Collective' as distinct from 'individual' competence is constituted in patterns of interaction within the team which enable it to make collective sense of challenging situations in the workplace. The capacity to construct collective understanding of this kind depends on the team possessing (and making use of) a collective knowledge base. Collective competence also depends on building and maintaining a sense of interdependency within the group. The other theoretical construct examined in this paper, work process knowledge, refers to knowledge of the business, production and labour processes in the organization as a whole. Employees in modernizing workplaces need such knowledge to underpin the wide collaboration, 'intrapreneurship' and cross-boundary activity expected of them. Work process knowledge is defined as 'active' knowledge which is directly useful for performance at work. It is constructed in the workplace, typically while solving problems, and doing so often involves synthesizing codified knowledge (e.g. theory learnt in the classroom, or procedures set out in manuals) with experiential knowledge acquired on the job. This paper explores ways in which these two concepts are connected. The primary link is that work process knowledge constitutes a significant part of the common knowledge base on which collective competence depends.

1. INTRODUCTION

One dimension in the continuing debate about the future of European VET is the impact of new forms of work organization on the knowledge and competencies required by the contemporary European workforce. This paper focuses on two concepts for analyzing these requirements: *collective competence* (Boreham, 2000a,b; Boreham 2004b) and *work process knowledge* (Boreham *et al.*, 2002; Fischer *et al.*, 2004). Specifically, the paper explores ways in which these concepts are related.

From the perspective of competency requirements, two key features of contemporary change in the European socio-economic order are - first, that creating and sharing knowledge is the basis for competitive advantage (implying that employees need more knowledge, and of a different kind), and second, that teamwork, collaboration and shared responsibility – not just individual effort – are increasingly being harnessed to promote corporate effectiveness. The concepts of *collective competence* and *work process knowledge* have been developed as tools for observing, understanding and theorizing these changes. In what follows, it will be argued that it is helpful to view work process knowledge through the lens of collective competence, for in this way, it appears less like a *commodity* and more like a *social accomplishment* - less of an *asset to be managed* and more of a *culture to be nurtured*. Such a perspective shift has significant implications for vocational education and training.

2. COLLECTIVE COMPETENCE

In the kind of innovative, organic, knowledge-creating company advocated by contemporary European economic policy makers, self-managing teams¹ are frequently introduced as the basis of the increasingly popular cellular work structure. This way of organizing work replaces the traditional hierarchical structure. In it, people and/or machines are grouped around information or product flows, reinforcing the identification of the team with its own product or service and increasing the capacity of the organization to respond to market changes. Self-managing teams typically take responsibility for a whole product or service, integrate functions previously carried out by different departments, manage themselves without continuous direct supervision, evaluate their own performance and organize at least some of their own training (Appelbaum and Batt, 1994; Benders and van Hooft, 1999). The central idea is that the self-managing team functions as a single unit or collective, and for this reason it needs to be competent at the collective level.

Whilst in the UK, the use of the term ‘competence’ in the context of vocational training usually refers to the performance of individuals, in fact the New Oxford Dictionary of English defines competence as “the scope of a person *or group*’s knowledge or ability” (emphasis added). This is because it makes as much sense to talk about the competence of a team as it does to talk about the competence of an individual member of that team. To say that a team is competent *might* mean that all its members are competent to discharge some function individually. However, the attribute of competence also applies to the kinds of collective performance which cannot be decomposed into an aggregate of individual competencies. Acknowledging the collective sense of the term ‘competence’ helps to explain why, for example, a firm of solicitors can remain competent at conveyancing property despite the retirement of experienced partners and the

recruitment of novices. When work is carried out by a team, with junior employees working with mid-career people and more experienced colleagues, the collective competence of the firm is located in working relationships between them, and these are relatively immune to the coming and going of individual employees. The essential collectivity of much legal work is reflected in the custom of signing the name of the firm, not the name of an individual solicitor, on official correspondence.

As an example of collective competence, consider Weick and Roberts's (1993) study of crews working on the flight decks of aircraft carriers. This shows how the crews work as single units, guided by a collective mind which comes into existence when each individual member gives conscious attention to the system-level consequences of his or her actions. By working in this way, crew members are socialised into a collective way of thinking similar to what Gustavsson calls interactive consciousness: 'The rules of the network of activities in the organization connect people: each member knows what needs to be done in relation to what others in the organization are doing and thus a group consciousness is created relying on the predetermined activities' (Gustavsson, 2001, p. 360). This form of collective competence cannot be represented as the aggregation of individual competences, as essential characteristics of collective competence – such as the interaction itself – does not exist at an individual level.

In a recent paper (Boreham, 2004b), the present writer proposed a theory of collective competence based on empirical studies of various occupational groups which frequently work as teams, including the staff of hospital accident and emergency departments (Boreham *et al.*, 2000) and process operators in the chemicals industry (Boreham and Morgan, 2002). The theory states three normative principles to which a team or group must conform if it is to act competently at the collective level.

- **Making collective sense of events in the workplace**

The first requirement for a group to deal competently with a problem is to make sense of the situation. Faced with a challenging situation, individuals feel incomprehension and fear, but this can be dispelled by positioning themselves within the more ordered structure of collective experience. Research by Eide (2000) suggests that a typical response to challenging situations is a spontaneous discussion between workers. This is not primarily a search for a technical solution to the problem, but an exchange of *feelings* about the situation, and it focuses on defining the boundaries of the occupational roles of those involved. Ultimately, this becomes an attempt to preserve personal identity. The challenging situation provides material for narratives or stories which are exchanged within the group; according to Eide, the collective re-interpretation of these stories is the primary way in which the group makes sense of what is happening to it.

- **Developing and using a collective knowledge base**

For effective narration to take place, the group must possess knowledge resources. Research on the use of language in the workplace indicates that many organizations develop specialist sub-languages tailored to the specific events in their domains (von Krogh and Roos, 1995). Even if they do not possess a specialist language, it is common to find a rich 'organizational memory' to which the organization's

members have access. Concepts of the work process formed in this way are maintained as concepts over time, and organizational members continue to bring these up in their conversation and thinking. The term ‘collective knowledge’ refers to the epistemic precondition for this kind of language use (Boreham, 2000a). The suggestion that an organization can possess collective knowledge over and above the knowledge of its individual members is not particularly radical if we consider how knowledge is embedded in language and other artifacts such as computer systems. The organization’s collective knowledge is maintained and renewed as individuals interact with these artefacts, and through them, with each other (cf Lammont and Boreham, 2002). As von Krogh *et al.* (1996) put it, ‘Individuals may leave the group (for example, a physicist may retire from his [or her] department and field) but the knowledge of the group does not vanish’ (p. 178).

- **Developing a sense of interdependency**

Team activity requires co-operation and communication between individual members, and this depends on the team’s capacity to overcome the fragmenting tendencies of their different orientations and perceptions. The team thus needs a powerful sense of interdependency, without which the members may act without regard for the collective purpose or each other’s needs.

To locate this concept of collective competence in a real world example, reference can be made to Weick’s (1993) account of the Mann Gulch disaster. Weick’s paper was a secondary analysis of an original study by MacLean (1992) and it is re-presented here as an example of a *failing* of collective competence. In the summer of 1949, the State of Montana Fire Service ordered a team of firefighters (“smokejumpers”) to parachute down on a fire in Mann Gulch. Their task was to encircle the fire and clear away vegetation to prevent it spreading. All the team members were part-timers, either students or men called out from their day jobs. Soon after they landed, however, they were encircled by the spreading fire when it jumped unexpectedly across the Gulch. As harrowingly told by MacLean (1992), the team structure disintegrated and each man struck out on his own for a nearby ridge where there might be a chance of dodging the flames. By acting in this way, Weick says, they demonstrated their failure to understand the true nature of the threat. Uncomprehendingly, they ran past the most experienced member of the team who was busying himself with the seemingly crazy act of setting fire to scrub. But he was the one who survived, by lying down in the burnt area he had cleared, whilst those who disregarded his shouts to join him lost their lives when the fire overtook them on their race to the ridge.

According to Weick, the men lost their lives because the team lost its capacity to make sense of what was happening. When the smokejumpers landed at the Gulch, they had a clear vision of what faced them – ‘what they had come to call a 10:00 fire ... one that can be surrounded completely and isolated by 10:00 the next morning’. But there was a collapse of sense making and the team became ‘unable to make any sense whatsoever of the one thing that would have saved their lives, an escape fire’ (pp. 633-5). Weick sees this as the primary cause of the disaster, and the case illustrates a lack of collective competence as defined above. However, although Weick concentrates on the team’s inability to make collective sense of its predicament, in fact MacLean’s study supports the other two elements of our definition of collective competence. As the smoke jumping team was assembled in a very *ad hoc* way, and had very little prior experience of

working together, they lacked a sense of interdependency. Moreover, their common knowledge base about fire fighting was minimal – little more than a brief instruction to form a circle round the fire, then clear vegetation with the tools provided. Arguably, the ability to make collective sense of a situation depends on having a common knowledge base which can be mined, and a well-ingrained sense of interdependency.

3. WORK PROCESS KNOWLEDGE

The definition of work process knowledge (Boreham *et al.*, 2002; Fischer *et al.*, 2004) is based on empirical research into the competence requirements of modernized workplaces, especially those which have undergone a transition from Taylorism (strong hierarchy, top-down decisions, segmented work roles and fixed working procedures) to organic structures allowing more participation in decision making, flexible labour processes and the involvement of all grades of employee in continuous improvement. The essential claim that underpins the theory of work process knowledge is that in the latter kind of working environment, employees need system-level understanding of the work process in the organization as a whole. This is necessary to enable them to understand how their own immediate tasks interconnect with operations carried out in other parts of the overall system. Understanding these interconnections provides underpinning for the patterns of interaction expected in modernizing workplaces, especially the assumption of responsibility for continuous improvement of working practices and autopoietic adaptation to customer/market requirements and the operational needs of other work units. Work process knowledge was defined by the EU Framework IV WHOLE project (Boreham *et al.*, 2002) in terms of four main attributes:

- It is a systems-level understanding of the work process in the organization as a whole. Here, ‘work process’ is a portmanteau expression which includes the *business process* – the overall configuration of the commercial and/or productive capacity of the company which enables it to respond to market demands; the *production process* – the range of commercial and/or industrial tasks performed across the company, such as design, machining and quality inspection, and how these interrelate to each other; and the *labour process* – the way the workforce is deployed in order to carry out these tasks; for example, who is responsible for which decisions, and the roles carried out by different members of the organization.

This way of defining work process knowledge focuses on its content, the breadth of purview demanded by cross-functional working and lateral communication. However, empirical research conducted by the WHOLE network suggested that further terms need to be added to this definition in order to provide a more complete picture of the knowledge employees actually use in modernizing workplaces. Consequently, the second term in the definition is that work process knowledge is ‘active’. The distinction between ‘active’ and ‘inert’ knowledge was made by Perkins (1992). Any knowledge can be judged active or inert in relation to a given activity. It is active if possessing it enhances performance in that activity – for example, knowledge of a musical score is active knowledge for the musician performing the music, because it enables him or her to produce the right notes. However, knowledge of the value of the shares of a company in which the musician has no interest is inert (at least, in relation to

his or her musical performance), as it does not have an impact on the way the music is played. Thus:

- Work process knowledge is used in the performance of work – it is ‘active’ as opposed to ‘inert’ knowledge.

However, the definition as it now stands is still not sufficient to account for the phenomena that researchers observed when they were investigating work process knowledge in contexts such as electrical maintenance (Vidal-Gomel and Samurcay, 2002) and medicine (Boreham *et al.*, 1992). Such research into how work process knowledge actually guides work resulted in the rejection of a simple cause-effect model and the adoption of a model in which work and work process knowledge are co-configurative - the knowledge (partially) guides the work and the work (partially) constructs the knowledge. Research carried out by WHOLE participants suggested that the construction of work process knowledge was often part of the response to a problem, especially when understanding and/or solving the problem required stepping out of a narrow work role or fixed procedure and negotiating or collaborating with people in other parts of the organization. This resulted in locating the theory of work process knowledge within a constructivist (as opposed to a representationalist) epistemology. Representationalism depicts knowledge as a state inside people’s heads which mirrors, by means of internal images, what is occurring in the world outside. An example of a representational view of work-related knowledge is Ochanine’s (1978) theory of operative images, which he defines as mental models of complex industrial plants formed inside the heads of the process operators who control them. The latter allegedly control the plants by consulting their mental models, a type of introspection which tells them what actions to take (for a critique of this theory, see Boreham, 1988). In opposition to this, constructivist epistemologies reject a dualism of inner and outer worlds, arguing that knowledge is fashioned publicly through social interaction and that it is embedded in social structure. Hence:

- Work process knowledge is constructed by employees while they are engaged in work, particularly when they are solving problems.

However, further aspects of the research carried out by the WHOLE network suggested that work process knowledge is more than mere know-how accumulated by years of unreflective practice. Rather, it is the result of reflection on problems in the workplace which generates new knowledge out of diverse knowledge resources including ‘theory’ (Boreham, 2004a). Thus:

- In place of the binary opposition between ‘knowing how’ and ‘knowing that’, work process knowledge is typically constructed by synthesizing codified and experiential knowledge in a dialectical process of resolving contradictions in the workplace.

To position this abstract definition in a real-world case study, reference can be made to Mariani’s (2002) investigation of an Italian knowledge-creating chemical company, carried out as part of the WHOLE project. This example is particularly apt as it shows the functionality of work process knowledge within the kind of organizational restructuring which companies often undertake in response to international

competition. Challenged by increasing competition in the field of plastics manufacturing, this company changed its business plan, switching the emphasis from manufacturing to research and development. Previously, research and development had constituted 20% of the business and manufacturing 80%, but these proportions were reversed and the core business became researching new types of plastic, developing the technology to produce them and licensing the resulting processes to other companies. In a very real sense, the Italian company became a knowledge creating company - the product it sold was knowledge.

The research and development activity was carried out in the company's laboratories and pilot chemical plants. New types of plastic were developed in the laboratories and then the pilot plants, small-sized production facilities, sought to develop new technological processes for manufacturing the new substances. Thus in place of chemical products, this knowledge creating company was producing patents for new plastics and the technological knowledge needed to manufacture them (the formulae would have been of limited value without a proven manufacturing process for them). Profit depended on patenting as many new processes as possible, so the pilot plants had to be reconfigured for many experimental production processes each month. This meant that the employees operating them had to work very much more flexibly than is usually the case in continuous process manufacturing. Not only were they stepping into new work roles several times each month as new technologies were tried out, but all grades of worker were involved in evaluating the new processes as part of their regular duties as pilot plant operators – in effect, knowledge creation had become their work. In order to cope with this new way of working, they needed to understand the work process as a whole: as one experienced employee commented, 'It should never be allowed to happen that an individual cannot interpret a certain output because he or she does not know what happened at a previous stage in the process' (Mariani, 2002, p. 24).

The transformation of the company entailed a new approach to training and work-based learning. The induction of new workers now placed more emphasis on understanding the production process as a whole and less on training them for specific roles. Extensive use was made of meetings and other ways of structuring conversations to promote continuous dialogue among employees about production methods - it was through this dialogue that employees constructed the understanding of the work process which enabled them to run the pilot plants innovatively. Moreover, it was in these meetings that the workforce synthesized scientific knowledge and practical know-how as they grappled with the problems of creating, implementing and evaluating new plastics technologies. Work process knowledge in all its aspects was an essential resource for the company's business process, and it was being constructed continuously in the workplace.

4. COLLECTIVE COMPETENCE AS THE CONSTRUCTION AND ENACTMENT OF WORK PROCESS KNOWLEDGE

A case study

The links between work process knowledge and collective competence can be explored by reference to a study carried out for the Framework V ORGLEARN project. This was a study of MultiNational Oil (a pseudonym), which operates a

1800-acre oil refinery and petrochemicals manufacturing complex in England. In a study of this company, Boreham and Morgan (2004) describe the transformation of the refinery from a hierarchical bureaucracy into a more organic type of organization with a strong commitment to continuous improvement. The present analysis of the case focuses on the way this transformation emphasised teamwork and collective competence, and identifies the enactment of work process knowledge as an essential part of collective competence.

The key changes in the company's way of working were:

- Re-organising more of the work in self-managing teams, and delegating to these teams a high degree of authority for developing new working methods
- Merging functional departments into multi-functional business units, and promoting cross-site collaborative work (previously, different shifts, departments and divisions did not interact much, but now they worked together across the site and indeed across the European continent)
- Extensive communication, both laterally and horizontally, by means of the intranet and the holding of frequent meetings; 'all-to-the-table' negotiation e.g. over performance targets, has replaced top-down management cascade

The new approach to work illustrates prioritizes a collective view of competence and the development of work process knowledge to underpin it. One of the types of team activity studied in the research was a systematic review of operating procedures known as the Procedures and Competence Development Methodology (PCDM). This activity, described in more detail in Boreham and Morgan (2002; 2004), took the form of small task forces drawn from the five different shifts to compare different ways of doing a given task, pool their knowledge and suggest best practice. One intended outcome was revised standard operating procedures. Another intended outcome was the development of competence (as the name of the initiative suggests) and this was essentially a collective competence. Previously, there was a highly individualized work system in which each operator kept a personal notebook with his or her own rules for operating plant – PCDM replaced this by agreements of best practice which were posted on the intranet as a shared knowledge base.

PCDM begins with a system-level analysis of all the operations in the refinery, leading to the selection of a task for investigation and exploration of the activities up-stream and down-stream of that task. Consequently, part of the development of collective competence through this methodology is the construction of a shared knowledge of the work process and agreed best practice for carrying out the task in question. The collective ethos is expressed in the company's policy document for PCDM which describes its intention as creating 'a culture of shared knowledge for the common good'. The following interview extract gives a participant's account of the procedure:

If you have got 5 shifts, you have got 5 different ways of doing things, if you have got 15, you have got 15 different ways of doing things. The most amount of time [in the organizational enquiry] is spent on get[ting] the

common ground out, and then once you have got the common ground, say ‘Well the consequences of this, that and the other are ...’ and then develop the best practice for it. And once you have done that you can then write the final operating procedure. [Interviewer: Does it change the way people work?] Yes, it does change. You might find that myself at one shift had a certain element of incidents all the time, and another shift didn’t. Well, obviously that other shift has got a better way of doing it. And it might be one shift pushing the feed up too quickly, for example, yes. But then again it might be the guys haven’t got that good a handle on what was happening ... and that brings together, get better at your activities.

By reaching agreement on their interpretations of common experiences, the workforce develops a collective knowledge base:

We are able to seep back a lot of information. We have found little holes in some of the systems, and this sort of thing ... We have got a good common knowledge now [interview with another employee].

Many interviewees stressed that the collective nature of the Procedures and Competence Development Methodology was crucial in bringing this about:

The important aspect of [the Procedures and Competence Development Methodology] is that it's done by consensus, by the whole of the group that's going to be involved.

By getting [the operators] to take ownership of everything, it sort of gets into the culture of things....

The following example illustrates how PCDM underpins collective competence, and highlights the co-construction of work process knowledge as an essential part of competence building. Following PCDM, a team of operators wrote procedures for gaining better control of the refining process at ‘critical control points’ (stages which critically affect the quality of the product). Following the agreed PCDM procedure, they discussed the data they had collected with the head of operations and the refinery technologists in their plant. These data revealed that one section of the process went into alarm for a variety of reasons on a large number of occasions, indicating the presence of a design fault. Extensive dialogue between the process operators and the refinery technologists about the need to re-engineer that part of the plant led to a decision to take a re-engineering project forward. This activity has the characteristics of collective competence as defined above – making collective sense of a problem through narrating, using a collective knowledge base and a high level of interdependency. The knowledge used to solve the problem included work process knowledge, a system-level analysis of the production and labour process including events upstream and downstream. This was constructed through the dialogue between the different members of the PCDM team, synthesizing the different perspectives of manual operators and graduate chemical engineers. Work process knowledge thus enters into our definition of collective competence by providing a significant part of the shared knowledge base.

Discussion

How can we theorize the connection between collective competence and work process knowledge? An explanatory framework can be found in socio-cultural theories of work and work-based learning. Central to these theories is the role of artifacts in mediating learning and communication. Leont'ev (1978) depicted artifacts as the product of human culture, social *objects* and the means by which human thought is developed and expressed. In the case analysed, the work of the PCDM teams results in a set of operating procedures which are placed on the company intranet in the form of reference task analyses and affixed to equipment in the form of job aids such as flow charts. These artifacts are symbolic tools which embody the work process knowledge that emerges from the teamwork we have described. Mediation, the basis of collective activity in socio-cultural theory, occurs when people use symbolic tools to regulate their activity - this is exactly how the standard operating procedures are used. Vygotsky explains that, as people engage in joint activity in pursuit of a goal, the ways in which they think and act accommodate themselves to the functions and limitations of the tools in use. The development and transmission of knowledge and skill in a community can then be explained by the progressive acquisition of socially constructed capacities which result from carrying out operations with these tools. Thus in the oil refinery, employees accommodate themselves to the standard operating procedures, and the standard operating procedures are accommodated to the ongoing activity of the teams who write them.

Leont'ev (1978) insisted that tools are not just physical artifacts – they incorporate a ‘social utilisation scheme’. By this is meant the complex of social practices that are ‘attached’ to the tool, in the sense that these are how the tool is perceived within the culture in which it is used (cf Lammont and Boreham, 2002). The concept of a utilisation scheme is crucial for explaining how work process knowledge underpins collective competence - it is not the physical artifact, but *the culture of its use* that enables competent performance. This is revealed in the interviews which made it clear that the standard operating procedures were not perceived solely as physical operations (turn this valve then switch on this pump, etc.) but as symbols of the new culture of continuous improvement and cross-boundary collaboration. As two refinery interviewees said:

Procedures and Competence Development Methodology, I feel, is more of a culture thing, it's not a cold process thing. It's a culture thing, you've got to believe in it and you've got to believe that without this you ain't gonna perform ...

I don't think it's just a case of getting a consensus on the procedure It's a change in attitudes, attitudes to working practices. A lot of these sound like clichés, but it's things like in pride of ownership of the kit ... If something falls over, it's not a maintenance issue, it's also an operations issue and very often it affects process-production, which costs big bucks ... it's a general state of mind.

If we see work process knowledge as existing in the form of artifacts in the sociocultural sense, and recognise that these artifacts are material things accompanied

by social utilization schemes, one way of describing the relationship between collective competence and work process knowledge is that collective competence is an *enactment* of the social utilisation scheme for a particular body of work process knowledge. The English work 'enact' means 'to put an idea, belief or suggestion into practice'. In the Italian chemical company, the collective competence of the teams in developing new manufacturing procedures involved putting their shared understanding of the work process into practice as they sought ways of making new plastics products. In the English oil refinery, the collective competence of the teams in promoting continuous improvement involved enacting a shared model of best practice – which went beyond turning valves. By enacting something, Weick (1995) points out, we create the environment in which we are situated - by enacting laws, a community actually creates a new social structure which then constrains the actions of its members. In the example of technological innovation in the Italian pilot plants and PCDM in the English oil refinery, teams devised new operating procedures and thus created a new working environment for themselves.

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¹ The term 'self-managing team' is used throughout for convenience, while fully recognizing that completely self-managing teams are rare. The expression should really be 'partially self-managing teams' or 'substantially self-managing teams', but this usage is avoided because of its clumsiness.