Chapter 3
Defining the Problem: Four Epistemic Projects in Professional Work and Education

> So they don't just become a registered nurse – they're always looking at improving their education, looking at evidence based practice, doing in-service when they're working. Always looking at making it more effective. <. . .> [F]rom the very first semester, the idea behind the practice development was to instil that that this is what you do for ever as a registered nurse. This is the practice we want you to be thinking about. (Nursing Practice Coordinator)

3.1 Crafting Expert Practitioners

When we asked university teachers to describe what students learn in professional practice courses, we were struck by a *commonality* in their teaching agendas and by the *diversity* of their answers about how they do this. Many teachers started to describe their courses by explaining recent 'paradigm shifts' in their respective professional areas. The examples that they gave included a shift from dispensing medications to improving the quality of the use of medicines and improving overall community health (in pharmacy education), the introduction of a new conceptual framework that entirely restructures the arts teaching curriculum (in teacher education) and a shift to continuous improvement of patient-centred care (in nursing education):

> There is a significant push, not only [here], but internationally, to reduce the amount of remuneration pharmacists receive for dispensing a medicine, and instead, remunerate them for improving quality use of medicines or health outcomes. So it's a major paradigm shift within the profession. (Pharmacy Lecturer)

How do university teachers prepare students for a changing world? Some of the aims and tasks associated with the professional practice courses featured in our research looked fairly mundane (e.g. to dispense a medication, to design an assessment task, to administer a literacy test), but some of them were much more future oriented and challenging (e.g. to design an ideal pharmacy layout, to create

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an evidence-informed nursing guide for manual handling, health assessment or infection control).

Broadly speaking, all of the examples uncovered in our empirical research differed in their details, but all were aimed at achieving something along one or more of the following four lines. That is, they were underpinned by one or more of the following rationales:

1. Giving form to the combination of professional 'mind' and 'action', that is, mapping and mixing 'theories' and 'evidence' learnt at university with certain kinds of practical knowledge. Examples included such tasks as reflecting on professional experiences or developing a plan or strategy.
2. Climbing into a professional 'skin': getting the body, mind and materials to act together (e.g. getting the pitch of one's voice right when teaching), doing what professionals do and feeling how they feel (e.g. thinking and feeling like a nurse).
3. Challenging students' minds with future-oriented ideas and with changing conceptions of their professions (e.g. creating an ideal pharmacy layout, developing a disease state management service).
4. Going 'outside the box' of professional skill and knowledge and engaging with practices at the intersections between different professional fields, with their different ways of knowing (e.g. for trainee pharmacists, talking with a doctor; for preservice teachers, knowing who the school social worker is and what they do).

All of the examples we observed involved grappling with some 'wild' – untamed and complex – challenges characteristic of their professions: the diversity of students', patients' and other clients' needs, multiple policy requirements, discrepancies between evidence and demands, contingency of professional decisions, etc. When 'wrapped' into simple specifications for student assignments, the tasks we observed clearly reflected some key practical and epistemic challenges in professional learning. On the one hand, there is the need to 'pack' the diversity of professional issues into a manageably small number of shapes and responses that students can learn. On the other hand, there is the challenge of adding to any form of professional knowledge the possibilities for infinite variation that will be encountered in real-world professional practice:

> People don't realise school counsellors cover from basically from three and half year olds to 18 year olds. So all of primary and secondary and special education – kids with disability. So it's really wide. So to fit all that expertise and range is very hard. <...> I don't expect them [students] to leave the university fully formed. I expect them to leave fully qualified to do it. But I'm not expected – I've covered everything – it's just impossible because it's such a wide ranging job. So I don't feel that it all hangs on that [Tasks that students do in the course]. (School Counselling Lecturer and Program Director)

In a variety of ways, the professional educators with whom we spoke tried to help students render the real world so that it looked more compactly 'conceptual' and render the conceptual world to make it feel more diverse, realistic and concretely 'material'. The teaching aims of these courses were underpinned by a notion of the 'mindful professional' – someone able to fuse theoretical knowledge with a

Table 3.1 Four epistemic projects of professional learning

	Rationale underlying tasks set for students	Challenges for professional learning	Epistemic projects
1	Giving form to mind and action	Linking theory with practice	Reflective rational
2	Donning a professional skin	Forming fine-tuned professional skills and identity	Reflective embodied
3	Challenging minds with future developments	Creating knowledge for the future	Knowledge building
4	Going outside one's professional box	Working with other professionals and clients	Relational expertise

common-sense grasp of the situation, formal rules with creativity, standards with improvisation and reason with intuition.

How can students learn to think and act as professionals? Indeed, how can they come to *be* professionals? Most of the things that students find hard to learn in their professions tend to be concentrated around four challenges, each of which is linked to the four lines sketched above: linking theories with practice, developing professional skills and identity, designing professional artefacts for the future and working with other professionals and clients. In light of such challenges, how do universities 'craft' future professionals? How do students craft themselves as professionals? How do they participate in the collective crafting of future professions?

Table 3.1 summarises the four kinds of professional learning tasks and associated challenges that we identified in our observations and interviews with professional educators. (These tasks are primarily distinguished by their respective rationales.) The table also connects these to what we are calling the four main 'epistemic projects' in professional education. Each of these epistemic projects can be thought of as a kind of learning journey: a reimagining of professional knowledge and practice, through which one learns/inhabits this knowledge and practice. The relationship between these four epistemic projects is captured in Fig. 3.1, which can be understood as follows.

We start by drawing on the work of Pickering (1995) and Mulcahy (2011b), to contrast two views of professional learning: the *representational* and the *performative*. Each involves distinct kinds of 'epistemic tricks'[1] that students are supposed to master.

We can think of them thus:

- Representational: linking doing with knowing
- Performative: linking doing with being

The *representational* view emphasises the building of bridges between one's professional actions and articulated forms of knowledge. In contrast, the

[1] We use the phrase 'epistemic tricks' because it suggests mastering skills that are usually somewhat hidden in the fluent work of experienced professionals: tricks which can appear 'magical' or 'mystical' for a lay observer until explicated.

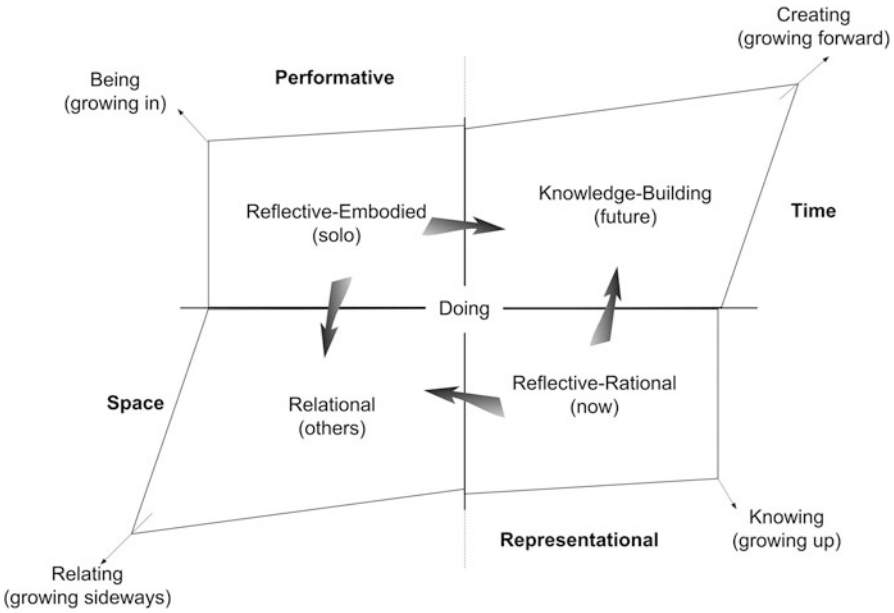

Fig. 3.1 Relations between the four epistemic projects

performative view foregrounds linking one's engagement with activities in the world to the development of the existential qualities of being a professional – qualities such as values and dispositions. While the representational view also acknowledges the critical role of professional qualities, it sees professional ways of being as emergent from knowledgeable action, rather than a direct focus for learning. Similarly, the performative view does not neglect the importance of professional knowing; rather, it sees knowing as emergent from professional coping with the world and becoming a professional, rather than being a direct focus for learning.

Next, we suggest that students have to go beyond *self*-representation and *self*-performance. They are also challenged to engage in professional work on the boundaries of their professions. One set of boundaries is *temporal* – extending doing and knowing from the past and present into the future. The other set of boundaries is *organisational* or *spatial* – extending doing and being from 'assembling the professional self' (Mulcahy, 2011b) to working across the boundaries of professional fields, crafting new professional assemblages and dwelling in what might be called 'trans-epistemic' spaces.

We argue that working in such dynamic spaces involves mastering all four sets of epistemic 'tricks' together. This capacity is one way of understanding what we mean by *epistemic fluency*. At the end of the book, we will extend this view by proposing a fifth project that connects the other four.

In the next part of this chapter, we describe in some detail these four reimaginings of professional learning, drawing connections where appropriate to existing writing about professional work and professional education. It may help to know in advance that our account moves towards a key idea about innovation in professional work that is fundamental to the book: the knowledge involved in a capability is not sufficient to improve that capability. We explain the significance of this in Sect. 3.7.

3.2 The Reflective-Rational Project: From Rational Knowledge to Reflective Practice to Rational Reflection

> In real-world practice, problems do not present themselves to practitioners as givens. They must be constructed from the materials of problematic situations that are puzzling, troubling, and uncertain. In order to convert a problematic situation to a problem, a practitioner must do a certain kind of work. He must make sense of an uncertain situation that initially makes no sense. (Schön, 2002, p. 47)

In broad terms, this first epistemic project can be traced back to the intersection of two lines of thought about (a) the link between theory and practice and (b) reflective thinking (cf. Dewey, 1910, 1938; Eraut, 1994; Schön, 1983, 1985). The pioneers of the pragmatic turn in education critiqued the positivist model of professional knowledge as an epistemic canon and made a distinction between reflective thinking and technical-rational thinking (Dewey, 1938; Schön, 1983). From the technical rationality perspective, practical knowledge is a form of applied science, and professionals should learn general problem-solving principles provided for them by the basic sciences and then develop skills in applying these principles in rigorous, proceduralised ways to the professional problems they encounter. The reflective project opposed this view, pointing to the uncertainty, uniqueness, value conflicts and other epistemic complexities of practical phenomena encountered in professional work. Real-world situations are irreducible to direct application of scientific principles; and, as Schön (1983) argued, practical knowledge involves a capacity to name the elements and frame encountered situations as problems. On this view, the epistemology of practice involves doing and thinking 'on one's feet'. Schön argued it is not only rigour but also relevance that should be the basis for professional knowledge. He suggested that such knowledge is best learnt by combining 'the teaching of applied science with coaching in the artistry of reflection in action' (Schön, 1987, p. xii). From this reflection-in-action perspective:

> ... professionals must be equipped with epistemological tools that can help them raise useful hypotheses, experiment with different candidate solutions and evaluate results. (de Souza, 2005, p. 32).

Schön (1987) also argued that professionals reflect not only 'in action' but also 'on action', suggesting that there is another layer of professional knowledge, knowing and learning – such as general principles – which is different from the knowledge

involved in the rapid decisions of concrete problem-solving and which requires a different kind of reflection. In relation to both reflection in action and reflection on action, Schön opposed the technical-rational view of a 'systematic knowledge base of a profession', seen as one that is:

> ... specialized, firmly bounded, scientific, and standardized. (Schön, 1983, p. 23).

Practical problems do not present themselves as neat cases or instances of scientific generalisations. Even when practitioners take time for reflection, they still think about problems in the language of practice and relevance, not in the language of scientific inquiry and rigour.

Schön's views on reflective practice are now widely recognised in higher education. However, they are not seen as universally applicable, and the reflective turn takes a number of modified forms.

For example, Schön (1987) was primarily interested in designers' work and 'designery' ways of knowing in action that, paraphrasing Latour (1990), are done by 'shuffling' papers: being 'thin' and 'slow' on the physical plane of action, but 'thick' on the epistemic plane of mental work:

> ... interacting with the model, getting surprising results, trying to make sense of the results, and then inventing new strategies of action on the basis of the new interpretation. (Schön & Bennett, 1996, p. 181)

Such thinking and action are not characteristic of all professions, particularly those that frequently require fast responses, such as in teaching, nursing and other health professions. Eraut (1994) and some others (e.g. Usher, Bryant, & Johnston, 1997) have questioned if, and how, reflection in action may happen in more dynamic professional work, arguing that Schön essentially overlooked some psychological realities of reflective thinking and underestimated pressure of time as a critical factor. Eraut (1994) noted that many practical decisions have to be made quickly and the scope for reflective thought is extremely limited in such situations. In these conditions, as Eraut argued:

> ... reflection is best seen as a metacognitive process in which the practitioner is alerted to a problem, rapidly reads the situation, decides what to do and proceeds in a state of continuing alertness. (Eraut, 1994, p. 145).[2]

Eraut also did not agree with Schön's clear-cut distinction between the theoretical or propositional knowledge invoked by 'technical rationality', in Schön's sense, and knowledge used in practical situations. As Eraut claimed:

> ... the use of such theoretical knowledge may not always be in the application mode stressed by the technical rationality model, but in the interpretative mode where it is more

[2] Eraut (1994) makes an explicit distinction between two meanings of reflection: 'metacognition' and 'deliberation'. Metacognition denotes alertness to, and control of, the ideas received from perception and sensations, but it does not involve deliberative consideration. Only 'deliberation' refers to serious consideration and deeper reflective thought 'the process of bringing personal knowledge under critical control' (p. 156).

> difficult to detect. Moreover, just because busy professionals do not use a particular idea, does not imply that they should not: that remains to be argued. (op. cit., pp. 103–104)

For Eraut, there *is* no clear-cut distinction between theory and practice. He agrees that the knowledge and knowing that underpin professional action should be of central importance in professional learning. He also agrees that the use of theoretical (propositional) knowledge in practical decisions requires considerable time and significant intellectual effort. But, in contrast to Schön, he argues that propositional knowledge needs to undergo significant transformation before it enters practice. So the process of interpreting and personalising theoretical propositions needs considerable support during professional education.

In higher education, these quite diverse views of knowledge and learning usually come in one 'pedagogical package' of *rational reflection*. This aims to use professional propositions and disciplinary concepts as lenses to reflect on professional phenomena and performance (Eraut, 1994, 2009; Roth, 2010; Schön, 1987; Wenger, 1998). In this way, the propositional kinds of theoretical and applied knowledge are linked with skill and performed practice.

Despite this commitment to action and practical knowledge, this view assumes that there is a canonical knowledge base of propositional or practical knowledge that all practitioners in a community should acquire. Examples would be the knowledge bases for teaching identified by Shulman (1986, 1987), and Shulman and Shulman (2004) or the professional competencies that need to be demonstrated and articulated for gaining professional accreditation in many professions.

This representational project underpins a range of well-known models of professional learning which are often regarded as very different, even incompatible, with each other (cf., Ericsson, 2006; Lave & Wenger, 1991; Schön, 1987). For example, as Mulcahy (2011b) notes, even the community of practice model (Lave & Wenger, 1991; Wenger, 1998), which articulates the idea of mutual constitution of meaning through a process of legitimate peripheral participation and negotiation, nevertheless carries a similar representational assumption and also assumes an ontological autonomy of the practitioner's understanding from in situ performance:

> ... participation in a community of practice implies that the professional who is making her becoming needs to *achieve a* '*fit*' with an established and somewhat enclosed structure. (Mulcahy, 2011b, p. 225, emphasis added)

Whether informed by action and a community-driven view of knowledge, foundational theories or sociopolitical concerns for accountability, the pedagogical account that underpins this representational view focusses on developing a certain relatively well-defined set of knowledge and skills that needs to be enacted, practised and fine-tuned to a variety of situations. Despite the focus on knowledge in practice, as Guile (2010) notes these pedagogies of reflection maintain a clear ontological separation between the mind and the world, and between theory and practice.

3.3 The Reflective-Embodied Project: Skill and the Ontological Turn in Practice

> ... we do not primarily access things conceptually or intellectually, but, instead, through being constantly immersed in activities, projects and practices with things and others. We organise entities and creatures within these projects: breed livestock and prepare food for our families, for example. We also alter or construct things, such as fell trees and build houses, or re-orient streams and rivers. To be this way requires that we are open to the possibilities of things—the qualities of timber or fresh produce, for example, and what those qualities enable. Things, in turn, need to be receptive to our manipulations. (Dall'Alba & Barnacle, 2007, p. 681)

A more radical turn, not only away from technical rationality but also from the 'intellect' as cognitive capacity, can be observed in other recent writings on the topic. This turn is towards the ontological project of professional practice and learning as 'being' (Barnett, 2004; Dall'Alba, 2009; Dall'Alba & Barnacle, 2007) and 'becoming' (Scanlon, 2011) – from *representation* to *performativity*. These writings have different roots: ranging broadly from existentialist ideas about 'receptive spontaneity' (e.g. Dall'Alba, 2009) to accounts that are more grounded in the physical world and socio-material practices of 'assembling a professional self' (Mulcahy, 2011a). This turn is primarily based on the assumption that the knowledge and skills that will be needed in future workplaces cannot be known, in advance, in detail or with any great certainty; thus, attention to 'knowing the world' and 'skills for doing' appears to be an unproductive focus for educating future professionals in higher education. Rather, 'being in the world' – pulling disparate elements of practice together into one 'assemblage of self' – needs to be at the centre of university teaching. As Barnett (2004) puts it:

> After all, if the future is unknown, what kind of learning is appropriate *for* it. <...> [T]he way forward lies in construing and enacting a pedagogy for human being. In other words, learning for an unknown future has to be a learning understood neither in terms of knowledge or skills but of human qualities and dispositions. (Barnett, 2004, p. 247)

Dall'Alba and Barnacle (2007) similarly question whether there is a universal form of professional knowledge, disconnected from experience, and they turn to a more contextually constructed and more pluralistic view of knowledge. They argue that (a) the current emphasis in higher education on knowledge and skills that are decontextualised from the practices to which they relate is flawed and (b) there is no one absolute universal knowledge; rather, there are knowledges that are situated, localised and 'socially constructed in relation to specific knowledge interests' (Dall'Alba & Barnacle, 2007, p. 680). This view challenges the primary focus of higher education on intellect, knowledge and transfer and suggests an alternative account of knowing that dislodges mind and reason from any kind of privileged – detached from the body and the world – position:

> Where a conventional account of knowing has treated it as restricted to an ideal realm of thoughts, ideas and concepts, we want to situate knowing within the materiality, and spatial and temporal specificity, of being-in-the-world. In other words, knowing is not reducible to thought or the discursive. Instead, knowing is always situated within a personal, social,

> historical and cultural setting, and thus transforms from the merely intellectual to something inhabited and enacted: a way of thinking, making and acting. Indeed, a way of being. (Dall'Alba & Barnacle, 2007, p. 682)

This line of thinking holds that professional education has become too concerned with epistemology, at the expense of ontology – a concern for the nature of being and the existential aspects of the profession. However, Dall'Alba's and Barnacle's 'ontological turn' is not so much the turn from epistemology to ontology, but to more ontological forms of knowing:

> . . . from epistemology in itself to epistemology in the service of ontology. <. . .> In other words, learning is not confined to the heads of individuals, but involves integrating ways of knowing, acting and being within a broad range of practices. (Dall'Alba & Barnacle, 2007, p. 683)

Some others have extended this ontological twist to lifelong learning – from 'being' to 'becoming' – emphasising the evolving and accumulative nature of knowledge and knowing (Scanlon, 2011). However, this performative project does not deny, in any strong sense, the existence of a knowledge base, foundational skills and core competences. As Scanlon (2011) claims:

> The acquisition of this recipe knowledge is a critical step in becoming a professional within the context of practice. (Scanlon, 2011, p. 15)

Dall'Alba (2009) similarly explains:

> Aspiring professionals need to develop necessary knowledge, routines and procedures for entering into appropriate caring relations with those whom they provide a service; ontology and epistemology are both implicated. For example, accountants need to develop knowledge and skills in accounting in order to provide ethical accounting services that respect the needs of their clients. (Dall'Alba, 2009, p. 141)

What is more at stake is the question of *what else* is needed when recipe principles and core knowledge fail to provide a sufficient basis for acting effectively as an expert professional practitioner. The main pedagogical suggestion that underpins this onto-epistemic project is that curriculum should be organised around core professional practices, meaning-making, reflexivity and identity:

> Allowing students to encounter and reflexively dwell in this dynamism and complexity. (Dall'Alba & Barnacle, 2007, p. 688)

There are several takes on this view of professional knowledge and learning. More existential accounts emphasise critical–reflective capabilities – so as to question professional assumptions and practices (e.g. Dall'Alba, 2009). In contrast, more socio-materialistic accounts emphasise the construction of the professional self across 'different discourses, material practices and positions' (Mulcahy, 2011b, p. 226). Nevertheless, the core pedagogical proposition is underpinned by a shared notion of performance: getting body, mind and hands (and heart) to act together in a coherent dynamic ensemble with the environment and the ongoing action. Mind and knowledge are not ontologically separated, by rational reflection, from the

world, embodied experiences and action. Knowing is being in the body and in the world: acting and reflecting. Accordingly, as Mulcahy (2011b) suggests, a curriculum for professional learning should be organised around the core professional practices, where skills, knowledge, identity and other professional qualities are developed 'in the process of learning to practice' (p. 240).

3.4 Representational and Performative Accounts and the Need to Cross Boundaries

The representational and performative views of professional knowledge and learning have significant similarities. Both projects acknowledge that professional expertise involves a certain set of 'core' skills and knowledge, and neither project questions the fundamental role of doing and experience in learning. Yet, the performative account of learning offers a pathway towards professional expertise that unfolds in a different direction from the representational account. The representational account starts from doing as a tacit form of practical knowing and proceeds *outwards* towards more articulated, explicit understandings which are independent from the situated action and environment. In contrast, the performative account starts from doing (and even articulated forms of recipe knowledge as a precondition for professional understanding) and proceeds *inwards* towards the existential, fusing understanding with the situated action and environment.

Both representational and performative accounts capture the nature of expertise and learning that might happen in (well defined) epistemically bounded knowledge spaces. In such spaces, professional knowledge is something that is already out of there in the form of explicit knowledge – expressed in symbolic representations or community discourses – or in the world, in its socio-material practices and arrangements. Thus, this knowledge either waits to be 'acquired' and 'transferred' or 'lived' and 'assembled' into a personal understanding and professional self. However, what kinds of knowledge and learning underpin expertise in a more *dynamic* and *epistemically diverse* professional world?

Being open to novelty and change requires engagement with innovation and multi-professional work. So we now offer two extensions of the representational and performative views of professional knowledge and learning: *temporal*, moving from what is known to creating new knowledge, and *organisational or spatial,* moving across epistemic spaces. These are the third and fourth epistemic projects represented in Table 3.1 and Fig. 3.1.

3.5 The Knowledge-Building Project: From Practice as Knowledge Transfer to Knowing as Epistemic Practice

> ... new knowledge is created also by professionals in practice, though this is often of a different kind from that created by researchers. Moreover, in some professions nearly all new practice is both invented and developed in the field, with the role of academics being confined to that of dissemination, evaluation and post-hoc construction of theoretical rationales. In others, knowledge is developed by practitioners 'solving' individual cases and problems, contributing to their personal store of experience and possibly that of their colleagues but not being codified, published or widely disseminated. (Eraut, 1985, p. 129)

It is now widely acknowledged that a range of professional innovations and organisational knowledge emerges from professional practices and problem-focussed design activity, rather than developmental work driven by basic research (Gibbons et al., 1994). Knowledge creation, innovation and transformation capacities have been seen as important qualities of successful practitioners and organisations (Argyris & Schön, 1996; Bresnen & Burrell, 2012; Engeström, 2008; Nonaka, 2004; Victor & Boynton, 1998). Some professions, such as architecture, engineering or computer programming, claim that such knowledge-building work is a part of everyday practice (Ewenstein & Whyte, 2009). Other professions aim to create similar practical knowledge, by trying to render current practices into codified forms (Goodyear & Steeples, 1998; Falconer & Littlejohn, 2009; Szymanski & Whalen, 2011). Knowledge that emerges from practice-based innovation is different in form and nature from the normative accounts of scientific knowledge; and the process through which such practical knowledge is created is distinct from the orderly normative models of scientific inquiry that (at least in theory) guide the production of formal scientific knowledge.[3]

It is often assumed that practical innovation and knowledge creation largely rest either on chance ('dumb luck' or serendipitous discovery) or on substantial amounts of experience. Either way, this makes innovative capability a quite esoteric, hard-to-learn skill. On this view, it would be difficult, if not impossible, to develop such capacities among university students who have little or no practical experience. For example, Nonaka and colleagues suggest that practical innovation depends on the conversion of tacit knowledge to explicit knowledge (Nonaka & Takeuchi, 1995; Nonaka & Toyama, 2007). Such knowledge gets created through continuous social interaction and is articulated, codified and made available for use in other settings. This knowledge creation process nevertheless tends to be quite mysterious, difficult to pin down and with tenuous links to pre-existing knowledge.

[3] We should emphasise that this argument primarily applies to *the normative* accounts of knowledge creation practices in research institutions. When we look at a range of ethnographies conducted in scientific laboratories (e.g. Goodwin, 1994; Knorr-Cetina, 1999; Latour & Woolgar, 1979; Lynch, 1988; Nersessian, 2006), it becomes more doubtful if the internal workings of scientific practices are very different from situated, contingent, messy and negotiated problem-solving in professional workplaces (e.g. Engeström & Middleton, 1996; Mol, 2002).

In contrast, Bereiter (2002a, 2002b), drawing on Whitehead's (1925/1948) ideas, argues that one of the distinguishing qualities of innovation over the last two centuries has been its *sustained* character (see also Mokyr, 2009). This kind of innovation is based on a 'disciplined progress' – 'a process of disciplined attack upon one difficulty after another' (Whitehead, 1925/1948, p. 92, cited in Bereiter, 2002a, p. 321). Bereiter illustrates this by describing the evolution of the television receiver since the mid-twentieth century – a process based on a series of small improvements:

> ... the basic design was established early; there were no further dramatic innovations in design, but instead a vast number of minor innovations. The end result ... was a device that continued to be structurally very similar to its prototype but with enormously improved performance and reliability. (Bereiter, 2002a, p. 321)

In more dynamic domains of professional work, such as the provision of new business solutions and other services, knowledge creation is a more mundane activity, not very different from individual, group and organisational learning (Argyris & Schön, 1996; Bereiter, 2002a, 2002b; Engeström & Sannino, 2012; Miettinen & Virkkunen, 2005). Moreover, on this view, knowledge creation can guide learning, and how to create knowledge can be learnt in formal education (Bereiter, 2002a, 2002b; Muukkonen & Lakkala, 2009; Muukkonen, Lakkala, & Paavola, 2011; Paavola & Hakkarainen, 2005; Paavola, Lipponen, & Hakkarainen, 2004).

The 'trialogical knowledge creation' (Paavola & Hakkarainen, 2005) or 'knowledge-building' (Bereiter, 2002b) approaches offer an initial framework for understanding the epistemic principles that underpin this view. As Paavola et al. (2004) explain:

> Learning could be understood as a collaborative effort directed toward developing some mediated artefacts, broadly defined as including knowledge, ideas, practices, and material and conceptual artefacts. The interaction among different forms of knowledge or between knowledge and other activities is emphasised as a requirement for this kind of innovativeness in learning and knowledge creation. (Paavola et al., 2004, pp. 569–570)

From this perspective, knowledge not only is the property of an individual mind but is embedded in mediating or conceptual artefacts – such as plans, theories, ideas and models – that are public and have an independent 'social life'. As Bereiter (2002a) argued, through joint work on conceptual artefacts, students can make their personal understanding explicit and accessible for further collaborative improvement. Students enhance their 'personal knowledgeability' by improving such 'public manifestations' of things they have in their minds. (Chapter 8 goes into much more detail about conceptual artefacts.)

The knowledge-building project is sometimes described in a romanticised way: extolling the virtues of the knowledge age, knowledge society and knowledge intensive economy. To hard-nosed sceptics, there is a credibility gap separating the innovation rhetoric of the knowledge economy and the mundane activities of everyday work. Talk of knowledge building may then seem a long way from the realities of practice and from the need to help students understand the propositions and principles germane to the profession or foster the skills of professional behaviour. Nevertheless, skilful and mindful tweaking of ideas and building new material

and conceptual tools for professional work are recognisable elements of everyday practice, though they are often overlooked in professional education (Bresnen & Burrell, 2012). Eraut (1985) argues that knowledge creation and knowledge use cannot easily be separated in practitioner problem-solving:

> The interpretative use of an idea in a new context is itself a minor act of knowledge creation. (Eraut, 1985, p. 129)

From this perspective, working on shared conceptual artefacts provides a meeting point between routine practice and innovation.

3.6 The Relational Project: From Individualistic to Relational Expertise

> All learning involves boundaries. Whether we speak of learning as the change from novice to expert in a particular domain or as the development from legitimate peripheral participation to being a full member of a particular community (Lave & Wenger, 1991), the boundary of the domain or community is constitutive of what counts as expertise or as central participation. When we consider learning in terms of identity development, a key question is the distinction between what is part of me versus what is not (yet) part of me. (Akkerman & Bakker, 2011, p. 132)

The discontinuities and tensions discussed above, particularly in relation to the first two epistemic projects, have emerged *within* the epistemological boundaries inherent in each professional domain. One can think of sociocultural discontinuities between university and workplace settings, or between different kinds of knowledge that constitute the internal workings and knowledge base of the profession, or between theory and practice, knowing, doing and being – these boundaries are *within* the epistemic space of the profession, thus internal to a broader notion of becoming an expert practitioner *within* one's professional domain.[4] Crossing these 'internal boundaries' – between school and work, learning and doing, etc. – has

[4] Akkerman and Bakker (2011) define boundaries 'as sociocultural differences that give rise to discontinuities in interaction and action' (p. 139). They identify two kinds of boundaries *within* and *across* domains and use *physical* sites with distinct sociocultural practices as the main criterion for locating the external boundary (i.e. boundaries *within* a school or *within* a work setting, but *between* school and work). In this book, we use an *epistemic* space of a profession, rather than a physical space or site of action, for demarcating the internal (within) and the external (across) boundaries of professional learning and expertise. That is, the internal workings shared within a profession for generating professional knowledge, learning, doing and being are the main criteria for deciding what is 'within' and what is 'between' and what is 'beyond' the boundaries of the profession. Thus, on our definition, the boundaries between the sociocultural sites that are located in the same professional space – such as between university and workplace, between different workplaces or between different levels of expertise (i.e. a novice and an expert) – are *internal* to the profession, whereas the boundaries between two professions (e.g. a nurse and a doctor) or between people who do not operate within the same epistemic space (e.g. a nurse and a patient, a teacher and a child) are *external* boundaries, across epistemic spaces. These external boundaries are the main focus of our discussions of the relational project.

dominated the literature on professional learning in higher and vocational education for decades (Billett, 2010; Eraut, 1994; Sternberg & Horvath, 1999; Tuomi-Grohn & Engeström, 2003). However, as Akkerman and Bakker (2011) note:

> ... various types of professional work (science, technology design, and teaching) are heterogeneous in that they involve multiple actors representing different professional cultures. <...> Hence, working and learning are not only about becoming an expert in a particular bounded domain but also about crossing boundaries. (Akkerman & Bakker, 2011, p. 134)

The expanding scale of such boundary work has been demonstrated in numerous studies of interdisciplinary, inter-professional, lay and professional and other kinds of joint work (e.g. Derry, Schunn, & Gernsbacher, 2005; Engestrom, 2004, 2008), Engeström & Middleton, 1996; Hutchins, 1995; Star & Griesemer, 1989). In some domains, such as architecture, design, media, healthcare, social work and other areas of public service, this kind of boundary expertise is not reserved to a specific group of people (such as a sales or customer relations team), but is a core part of professional competence. New accounts of professional expertise that includes the capacities needed to work on such epistemic boundaries have been emerging in a variety of professional and scientific domains (e.g. Collins & Evans, 2007; Edwards, 2010; Guile, 2010, 2011). Thus, the notion of professional learning has to be expanded to include the capacity to work on the epistemic boundaries of professional expertise, in trans-epistemic spaces.

Edwards (2005, 2010) has offered the idea of 'relational agency' or 'relational expertise' and defined it as:

> ... an additional form of expertise which makes it possible to work with others to expand understandings of the work problem as an object of joint activity, and the ability to attune one's responses to the enhanced interpretation to those being made by other professionals. (Edwards, 2010, p. 13)

She explains that this kind of expertise primarily arises from two dynamically interrelated sources: (a) recognising other professionals as resources and understanding what is salient for them and what they bring when they interpret the joint object of activity and (b) aligning one's own responses and actions to the emergent interpretations and actions of others. She argues that relational expertise involves both purposeful inter-professional activity and 'weaving' clients' private knowledge into professional decisions. While such decision-making does not necessarily involve established procedures or pre-existing ideas, such relational expertise can be learnt by working alongside others. That said, Edwards is very clear that core professional expertise is essential and she warns against 'the dilution of personal specialist expertise' (Edwards, 2010, p. 15).

This extension of professional competences and practices into trans-epistemic spaces is distinct from, and goes beyond, the *self*-assembling practices implied in the performative and representational accounts of learning. Boundary practices not only spill out beyond preconfigured epistemic space but also involve 'weaving in' other ways of knowing that assume particular languages, particular ways of seeing and particular forms of reasoning, doing and being. From the instructional point of

view, this relational practice goes beyond the self-assembling implied in the performative accounts of learning, to include assembling dynamically a *shared* material and epistemic space in ways that enable mutual understanding (Engeström, 2004; Goodwin, 2005). This view shifts the focus from reflective forms of learning to shared activities, discourse and objects that constitute the boundary infrastructure for the joint activity and meaning-making.

There are several views on what kinds of skills and understandings could provide a basis for such relational expertise (e.g. Bromme, Kienhues & Porsch, 2010; Collins & Evans, 2007; Guile, 2010, 2011). Some claim that such shared intelligibility rests on shared knowledge that precedes joint work – such as an 'interactional expertise' that involves enough practical understanding and ability to participate in the *discussion* of certain practices without having the knowledge or skills to *contribute* to those practices (Collins & Evans, 2007). Others claim that relational expertise requires an ability to bring knowledge that resides outside the practice of others into shared action and discourse during joint activity. For example, Guile (2011) suggests that such inter-professional work and learning becomes possible by giving and asking for reasons, and making judgements, in ways that are intelligible to people outside the professional field. In all cases, language, the understanding of the rules that people who come from a particular domain use to make sense and generate meanings and typical shapes in which knowledge gets expressed, play an integral role in developing the competences needed to work in trans-epistemic spaces.

The importance of such 'boundary' capabilities is widely recognised in higher education. For example, increasing attention is paid in professional courses to such things as nurses' and pharmacists' abilities to communicate with doctors, to teaching health professionals to communicate with patients and to creating opportunities for preservice teachers to engage in classroom management interactions before entering a real classroom. However, creating environments for authentic work with other experts or clients presents a significant challenge when one tries to engage students in *genuine* epistemic practices and to develop this competence in university settings. Linguistic practices, social interactions and the material affordances of heterogeneous practice settings (e.g. a classroom with children, interactions with a patient at home) cannot be easily simulated in conventional university learning environments. As Goodwin (2005) suggests, social and material authenticity matters as joint epistemic spaces are created not only by talk but also by juxtaposing tools and practices and jointly inhabiting a material environment.

3.7 Combining the Four Epistemic Projects: Knowledge for Doing and Knowledge for Innovation and Learning

> . . . we try and get them out of – not only physically but mentally – out of the pharmacy. But more and more so, disease management is about prevention. And pharmacists can help in that way. So it's really, as healthcare is changing, in a way, so is the role the pharmacist can

> change with that. <...> It's part of also relationship building with their clients, their customers. Customer loyalty and all that kind of stuff, develops out of providing something extra. (Pharmacy Practice Coordinator)

The four epistemic projects outlined above point to different notions of the knowledge that is needed for professional practice and different ways of learning it. But what kinds of knowledge and ways of knowing might underpin the very capacity to learn and change? We need to share some ideas from Victor and Boynton's (1998) book *Invented Here* to advance our argument. Victor and Boynton offer an insightful heuristic that depicts knowledge and processes on which organisations draw for maximising their internal capability and growth. They see organisational capability advancing along a path that goes through five stages – craft, mass production, process enhancement, mass customisation and co-configuration – and note that there is a tight link between the nature of capabilities, values and knowledge in each stage (Fig. 3.2).

Craft primarily draws on the tacit knowledge of individual workers. This stage of organisational capability values the uniqueness, novelty and invention that emerge from personal experiences and mastery of techniques and tools. In contrast, *mass production* is based on articulated knowledge. It is good at producing standard, low-price commodities, and this success is achieved by standardised processes, divisions of labour, specialised work and effective management and control systems. *Process enhancement* draws on practical knowledge that emerges from doing similar tasks repeatedly and tight links between doing and thinking. This stage of organisational capability values the quality of work and its outcomes and

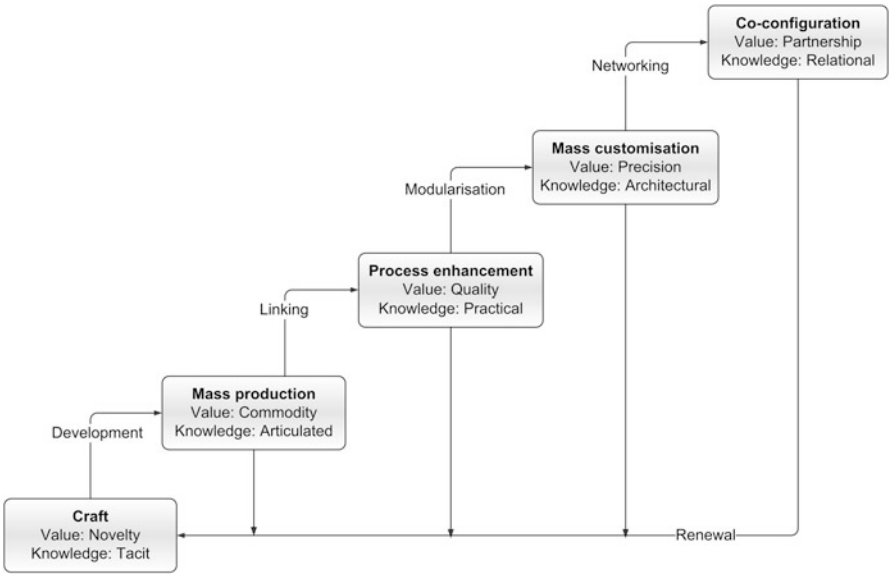

Fig. 3.2 Capabilities and transformations in organisational growth (Adapted from Victor & Boynton, 1998, p. 121, p. 233)

focusses on shared commitment to improving work processes – to continuing quality enhancement. *Mass customisation* draws on the architectural knowledge which tightly couples deep understanding of the products and processes. It values precision and focusses on producing things that are well suited to the diverse needs of different customers, through affordable, 'made-to-order' products and services. Such outcomes are achieved through analysing and breaking up products and work processes, such as by creating a network of easy-to-assemble elements. *Co-configuration* draws on relational knowledge to tailor products and services to better match customers' dynamically changing needs, allowing professionals together with customers to co-configure and reconfigure things. This capability focusses on creating 'customer-intelligent' products and services that are actively responsive and continuously adapt in synch with evolving customer requirements. Such an outcome is achieved by creating products that can be upgraded, enhanced or altered in other ways without replacing them and by establishing enduring partnerships with the customers that permit just-in-time responsiveness to their changing needs.

According to Victor and Boynton (1998), organisational growth is achieved by going through four (sequential) transformations: development, linking, modularisation and networking (or integration). Each stage draws on the previous capability, and specific tools, for achieving each transformation. During the *development* transformation, tacit craft knowledge is articulated and solidified into the development of processes and tools for mass production. It draws on various tools and techniques for articulation, such as product and process engineering. During the *linking* transformation, the practical knowledge acquired during the mass production process is used for improving this process. This transformation involves collaboration across teams, identification of inefficiencies, documentation, team building and other techniques and tools for process improvement. During the *modularisation* transformation, work capabilities are reconfigured into a network of modular units. This draws on architectural principles for identifying such modules, building their networks and creating ways to assemble finished products. During the *networking* transformation, knowledge about products and knowledge about customers are combined in a series of dynamic interactions. As Victor and Boynton put it:

> With co-configuration, there are no final products; no service is ultimately delivered. Instead, the boundaries between learning and work, customer and product, customer and company disappear. What replaces those boundaries are tightly coupled linkages, which feature constantly shared information, ideas, and experiences around the product or service experience. (Victor & Boynton, 1998, p. 207)

Each stage of capability is not only a reflection of organisational maturity but a more complex configuration of what customers value and what kinds of capabilities are most appropriate for delivering the best outcomes. For example, as Victor and Boynton show, in some service provision domains, customers may have privacy concerns and may not be willing to engage and provide sufficient information for configuring products and services dynamically to their changing needs. In some production industries, such as car manufacturing, the co-configuration of complex

mechanical products may be too risky and expensive. In short, one capability may be more appropriate than another when it comes to achieving the best value for the organisation and its customers.

However, none of the capabilities are static as, without the change, organisations cannot sustain their capacity to meet their clients' expectations in changing market conditions. Thus, one of the essential processes that underpins *all* capabilities is *renewal*. During such changes, organisations use their limited capabilities to serve certain clients by direct invention. They go back to the craft work that creates tacit knowledge. As Victor and Boynton say:

> ... the ultimate origin of all value: the unique insights and inspiration of the craftsperson – the human font of creativity. (op. cit., p. 182)

> ... tacit knowledge is real, but hard to describe. <...> Craft workers intuitively figure out how to respond to shifting customer demands and diverse market needs using a set of tools at their disposal, sense the urgency to react to a novel market, and have the freedom and motivation to do so. (op. cit., p. 22)

The dynamic depicted in this view draws on knowledge entailed in all four of the epistemic projects we sketched earlier in this chapter, including links between tacit, articulated and practical knowledge in the two reflective projects and architectural and relational knowledge in the knowledge-building and relational projects. It underlines the fact that a new capability draws on experience, skill and existing knowledge.

However, Victor and Boynton's account also makes it clear that knowledge *for work* (e.g. tacit and articulated knowledge) is not the same as knowledge *for improvement of work* (e.g. development and linking, respectively). The *capability for enhancing capability* does not emerge solely from accumulated experience or bold creativity. Rather, it involves the use of certain kinds of *tools*; it happens in certain *environments* and requires certain kinds of *knowledge*.

The knowledge, tools and environments needed *for* this change and learning are different from the knowledge, tools and environments entailed in the production of goods and services. They are *epistemic* knowledge, tools and environments: entailed in the production of *knowledge*. In making such transformations that underpin organisational growth, knowledge for *doing* work is weaved with knowledge for *constructing* this knowledge – i.e. epistemic knowledge.

Victor and Boynton primarily emphasise the nature of knowledge that underpins each organisational capability, but we also need to recognise that each capability is also underpinned by *a particular way of knowing*. These ways of knowing are particularly central in the organisations that *produce knowledge* as a part of their daily work. They include *epistemic intuitions* that underpin knowledge craft, *formal epistemic concepts and structures* that enable mass knowledge production, *epistemic practices* that underpin the skilful enhancement of existing ways of knowing, *epistemic infrastructures* that may be customised and adapted flexibly for knowledge work in particular situations, *epistemic sensitivity* that supports knowledge creation in partnership with others and *epistemic fluency* that allows professionals

to understand, switch between and coordinate different ways of knowing with awareness, sensitivity to the situation and skill.

In organisations that rely on dynamic change, these epistemic capacities become central skills for knowledgeable action and innovation in everyday work. They enable a shift from disruptive cyclical transformations and renewal to a more sustainable and continuous process of ecological innovation, change and professional learning.

As Cook and Brown (1999) claim, when apprentices engage in work practices – be it baking, flute making or designing copying machines – they develop not only knowledge but also *ways of knowing*. However, drawing on Geoffrey Vickers, they observe:

> It's funny what's happened to this word *knowing*. <...> The actual *act* of apprehending, of making sense, of putting together, from what you have, the significance of where you are – this [now] oddly lacks any really reliable, commonly used verb in our language ... [one] meaning the *activity* of knowing. <...> [Yet], every culture has not only its own set *body* of knowledge, but its own *ways* of [knowing]. (Vickers, 1976, cited in Cook & Brown, 1999, p. 381, original emphasis)

Indeed, the epistemic abilities needed to engage fluently with different *ways of knowing* are not salient in the literature and practices of professional learning.

This kind of fluency provides the basis for extending co-configurational forms of work. It also allows *personal* and *organisational* growth and renewal to be a more organic part of everyday practice, rather than a set of unique transformations that break with the past (Fig. 3.3).

Each of the accounts summarised in this chapter adds a new dimension to the epistemic puzzle of professions: what kinds of knowledge underpin professional action? What kinds of knowledge, skills and other qualities provide a sufficient

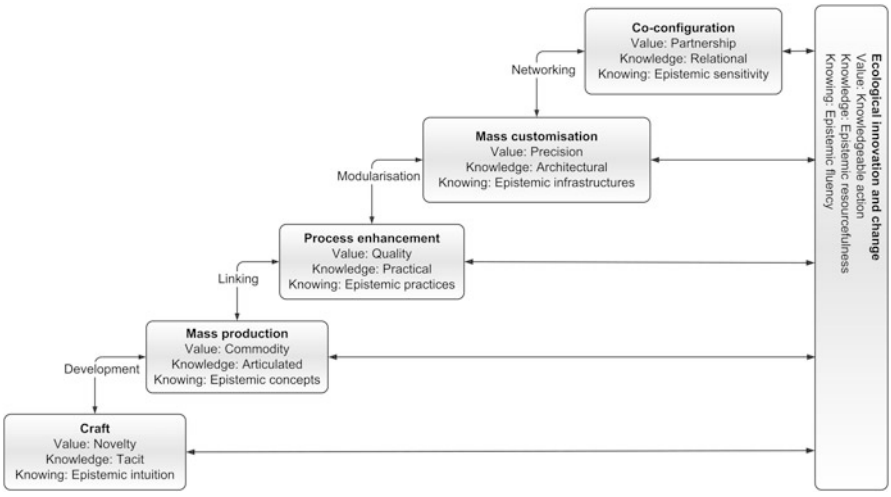

Fig. 3.3 Capabilities for sustainable, ecological innovation and change (Following Victor & Boynton, 1998)

basis for the development of skilful performance and professional expertise? The word 'development' is essential here. It would be foolish to think that preservice education in universities can create fully formed expert professionals. But it is reasonable to expect universities to prepare graduates who are competent to *start* doing the job and *capable of becoming* expert professionals. To lay the foundations for this professional development, university courses need to pay sharper attention to the constitutive elements of knowledge and the means by which professionals create new knowledge.

References

Akkerman, S. F., & Bakker, A. (2011). Boundary crossing and boundary objects. *Review of Educational Research, 81*(2), 132–169.

Argyris, C., & Schön, D. A. (1996). *Organizational learning II: Theory, method and practice*. Reading, MA: Addison-Wesley.

Barnett, R. (2004). Learning for an unknown future. *Higher Education Research & Development, 23*(3), 247–260.

Bereiter, C. (2002a). Design research for sustained innovation. *Cognitive Studies: Bulletin of the Japanese Cognitive Science Society, 9*(3), 321–327.

Bereiter, C. (2002b). *Education and mind in the knowledge age*. Mahwah, NJ: Lawrence Erlbaum Associates.

Billett, S. E. (2010). *Learning through practice: Models, traditions, orientations and approaches*. Dordrecht, The Netherlands: Springer.

Bresnen, M., & Burrell, G. (2012). Journals à la mode? Twenty years of living alongside Mode 2 and the new production of knowledge. *Organization, 20*(1), 25–37.

Bromme, R., Kienhues, D., & Porsch, T. (2010). Who knows what and who can we believe? Epistemological beliefs are beliefs about knowledge (mostly) to be attained from others. In L. D. Bendixen & F. C. Haerle (Eds.), *Personal epistemology in the classroom: Theory, research, and implications for practice* (pp. 163–193). Cambridge, UK: Cambridge University Press.

Collins, H., & Evans, R. (2007). *Rethinking expertise*. Chicago, IL: The University of Chicago Press.

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

Dall'Alba, G. (2009). *Learning to be professionals*. Dordrecht, The Netherlands: Springer.

Dall'Alba, G., & Barnacle, R. (2007). An ontological turn for higher education. *Studies in Higher Education, 32*(6), 679–691. doi:10.1080/03075070701685130.

de Souza, C. S. (2005). *The semiotic engineering of human-computer interaction*. Cambridge, MA: MIT Press.

Derry, S. J., Schunn, C. D., & Gernsbacher, M. A. E. (2005). *Interdisciplinary collaboration: An emerging cognitive science*. Mahwah, NJ: Lawrence Erlbaum Associates.

Dewey, J. (1910). *How we think*. Boston, MA: D. C. Heath.

Dewey, J. (1938). *Logic: The theory of inquiry*. New York, NY: Henry Holt.

Edwards, A. (2005). Being an expert professional practitioner: The relational turn in expertise. *International Journal of Educational Research, 43*(3), 168–182.

Edwards, A. (2010). *Relational agency: Learning to be a resourceful practitioner*. Dordrecht, The Netherlands: Springer.

Engeström, Y. (2004). New forms of learning in co-configuration work. *Journal of Workplace Learning, 16*(1/2), 11–21.

Engeström, Y. (2008). *From teams to knots: Activity-theoretical studies of collaboration and learning at work*. Cambridge, NY: Cambridge University Press.

Engeström, Y., & Middleton, D. E. (Eds.) (1996). *Cognition and communication at work*. Cambridge, NY: Cambridge University Press.

Engeström, Y., & Sannino, A. (2012). Concept formation in the wild. *Mind, Culture, and Activity, 19*(3), 201–206. doi:10.1080/10749039.2012.690813.

Eraut, M. (1985). Knowledge creation and knowledge use in professional contexts. *Studies in Higher Education, 10*(2), 117–133.

Eraut, M. (1994). *Developing professional knowledge and competence*. London, UK: Falmer Press.

Eraut, M. (2009). Understanding complex performance through learning trajectories and mediating artefacts. In N. Jackson (Ed.), *Learning to be professional through a higher education e-book* (Ch. A7, pp. 1–17). Guildford, UK: Surrey Centre for Excellence in Professional Training and Education (SCEPTrE). Retrieved from https://www.learningtobeprofessional.pbworks.com

Ericsson, K. A. (2006). The influence of experience and deliberate practice on the development of superior expert performance. In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 683–703). New York, NY: Cambridge University Press.

Ewenstein, B., & Whyte, J. (2009). Knowledge practices in design: The role of visual representations as 'epistemic objects'. *Organization Studies, 30*(1), 7–30.

Falconer, I., & Littlejohn, A. (2009). Representing models of practice. In L. Lockyer, S. Bennet, S. Agostinho, & B. Harper (Eds.), *Handbook of research on learning design and learning objects* (pp. 20–40). Hershey, PA: Idea Group.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. London, UK: Sage.

Goodwin, C. (1994). Professional vision. *American Anthropologist, 96*(3), 606–633.

Goodwin, C. (2005). Seeing in depth. In S. J. Derry, C. D. Schunn, & M. A. Gernsbacher (Eds.), *Interdisciplinary collaboration: An emerging cognitive science* (pp. 85–121). Mahwah, NJ: Lawrence Erlbaum Associates.

Goodyear, P., & Steeples, C. (1998). Creating shareable representations of practice. *Association for Learning Technology Journal, 6*(3), 16–23.

Guile, D. (2010). *The learning challenge of the knowledge economy*. Rotterdam, The Netherlands: Sense.

Guile, D. (2011). Interprofessional learning: Reasons, judgement, and action. *Mind, Culture, and Activity, 18*(4), 342–364.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: MIT Press.

Knorr-Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge*. Cambridge, MA: Harvard University Press.

Latour, B. (1990). Drawing things together. In M. Lynch & S. Woolgar (Eds.), *Representation in scientific practice* (pp. 19–68). Cambridge, MA: MIT Press.

Latour, B., & Woolgar, S. (1979). *Laboratory life: The social construction of scientific facts*. Beverly Hills, CA: Sage.

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

Lynch, M. (1988). The externalized retina: Selection and mathematization in the visual documentation of objects in the life sciences. *Human Studies, 11*(2), 201–234.

Miettinen, R., & Virkkunen, J. (2005). Epistemic objects, artefacts and organizational change. *Organization, 12*(3), 437–456.

Mokyr, J. (2009). *The enlightened economy: An economic history of Britain 1700–1850*. New Haven, CT: Yale University Press.

Mol, A. (2002). *The body multiple: Ontology in medical practice*. Durham, NC: Duke University Press.

Mulcahy, D. (2011a). Assembling the 'accomplished' teacher: The performativity and politics of professional teaching standards. *Educational Philosophy and Theory, 43*, 94–113.

Mulcahy, D. (2011b). Teacher professional becoming: A practice-based, actor network theory perspective. In L. Scanlon (Ed.), *"Becoming" a professional: An interdisciplinary analysis of professional learning* (pp. 219–244). Dordrecht, The Netherlands: Springer.

Muukkonen, H., & Lakkala, M. (2009). Exploring metaskills of knowledge-creating inquiry in higher education. *International Journal of Computer-Supported Collaborative Learning, 4*(2), 187–211. doi:10.1007/s11412-009-9063-y.

Muukkonen, H., Lakkala, M., & Paavola, S. (2011). Promoting knowledge creation and object oriented inquiry in university courses. In S. Ludvigsen, A. Lund, I. Rasmussen, & R. Säljö (Eds.), *Learning across sites: New tools, infrastructures and practices* (pp. 172–189). Oxon, OX: Routledge.

Nersessian, N. J. (2006). The cognitive-cultural systems of the research laboratory. *Organization Studies, 27*(1), 125–145.

Nonaka, I. (2004). The knowledge creating company. In H. Takeuchi & I. Nonaka (Eds.), *Hitotsubashi on knowledge creation* (pp. 29–46). Singapore, Singapore: John Wiley & Sons.

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

Nonaka, I., & Toyama, R. (2007). Why do firms differ? The theory of the knowledge creating firm. In K. Ichijo & I. Nonaka (Eds.), *Knowledge creation and management: New challenges for managers* (pp. 13–31). Oxford, UK: Oxford University Press.

Paavola, S., & Hakkarainen, K. (2005). The knowledge creation metaphor – an emergent epistemological approach to learning. *Science & Education, 14*(6), 535–557.

Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of innovative knowledge communities and three metaphors of learning. *Review of Educational Research, 74*(4), 557–576.

Pickering, A. (1995). *The mangle of practice: Time, agency, and science*. Chicago, IL: University of Chicago Press.

Roth, W.-M. (2010). Learning in praxis, learning for praxis. In S. Billett (Ed.), *Learning through practice: Models, traditions, orientations and approaches* (pp. 21–36). Dordrecht, The Netherlands: Springer.

Scanlon, L. E. (2011). *"Becoming" a professional: An interdisciplinary analysis of professional learning*. Dordrecht, The Netherlands: Springer.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York, NY: Basic Books.

Schön, D. A. (1985). *The design studio: An exploration of its traditions and potentials*. London, UK: RIBA Publications for RIBA Building Industry Trust.

Schön, D. A. (1987). *Educating the reflective practitioner*. London, UK: Jossey-Bass.

Schön, D. A. (2002). From technical rationality to reflection-in-action. In R. Harrison, F. Reeve, A. Hanson, & J. Clarke (Eds.), *Supporting lifelong learning: Perspectives on learning* (Vol. 1, pp. 40–61). London, UK: RoutledgeFalmer.

Schön, D. A., & Bennett, J. (1996). Reflective conversation with materials. In T. Winograd, J. Bennett, L. D. Young, & B. Hartfield (Eds.), *Bringing design to software* (pp. 171–184). New York, NY: ACM Press.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1–22.

Shulman, L. S., & Shulman, J. H. (2004). How and what teachers learn: A shifting perspective. *Journal of Curriculum Studies, 36*(2), 257–271.

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's museum of vertebrate zoology. *Social Studies of Science, 19*(4), 387–420.

Sternberg, R. J., & Horvath, J. A. (1999). *Tacit knowledge in professional practice: Researcher and practitioner perspectives*. Mahwah, NJ: Lawrence Erlbaum Associates.

Szymanski, M. H., & Whalen, J. E. (2011). *Making work visible: Ethnographically grounded case studies of work practice*. Cambridge, UK: Cambridge University Press.

Tuomi-Grohn, T., & Engeström, Y. E. (2003). *Between school and work: New perspectives on transfer and boundary-crossing*. Amsterdam, The Netherlands: Pergamon Press.

Usher, R., Bryant, I., & Johnston, R. (1997). *Adult education and the postmodern challenge*. London, UK: Routledge.

Vickers, G. (1976). *Technology and culture, invited paper given at the Division for Study and Research in Education*. Cambridge, MA: Massachusetts Institute of Technology.

Victor, B., & Boynton, A. C. (1998). *Invented here: Maximizing your organization's internal growth and profitability*. Boston, MA: Harvard Business School Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, UK: Cambridge University Press.

Whitehead, A. N. (1925/1948). *Science and the modern world* (Mentor ed.). New York, NY: New American Library.