THE PRODUCTION, MEDIATION AND USE OF PROFESSIONAL KNOWLEDGE AMONG TEACHERS AND DOCTORS: A COMPARATIVE ANALYSIS

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The most pressing need confronting the study of professions is for an adequate method of conceptualizing knowledge itself.
Eliot Freidson, 1994

Introduction

The are two grounds for undertaking a comparative analysis of the knowledge-base and associated processes of the medical and teaching professions. First, by examining the similarities and differences between the two professions, it should be possible to advance a generic model of a professional knowledge-base. Secondly, the contrast offers some indications of what each profession might learn from the other.

In this chapter, doctors and teachers are compared in relation to their highly contrasting knowledge-bases. Whereas the knowledge-base of doctors is rooted in the biomedical sciences, teachers have no obvious equivalent, and the attempt to find one in the social sciences has so far largely failed. Yet both professions share a central core to their knowledge-base, namely the need to generate systems for classifying the diagnoses of their clients' problems and possible solutions to them. Contrasts are drawn between the styles of training for doctors and teachers, with doctors having retained some strengths from an apprenticeship model and teachers now developing more sophisticated systems for mentoring trainees. In both professions, practice is often less grounded in evidence about effectiveness than is commonly believed, but practitioner-led research and evidence-based medicine have put doctors far in advance of teachers. Adaptations of some developments in medicine could be used to improve the systemic capacities for producing and disseminating the knowledge which is needed for a better professional knowledge-base for teachers. There may be aspects of knowledge creation and dissemination where teachers have a small advantage over doctors.

A generic model of the professional knowledge-base is proposed. The model and the analysis are then set within the wider context of the changing process of knowledge production.

Science and the professional knowledge-base

Qualified medical practitioners are universally accepted as a profession with relatively high levels of autonomy, prestige and privilege. Despite the many national differences in the political and institutional arrangements for the provision of health care that affect the social position and clinical freedom of the doctor (Freddi and Björkman, 1989; Hafferty and McKinley, 1993; Johnson, Larkin and Saks, 1995; Wall, 1996), they almost everywhere enjoy high social standing. Most school-teachers would like to be so regarded, and may even lay claim to professional status, but are usually seen to fall short of being full

professionals. Unlike doctors, school-teachers lack the esoteric knowledge-base that is a key characteristic of professions (Larson, 1977).

The knowledge-base of doctors has shifted over the centuries. Today it is seen as essentially scientific in character, despite the considerable differences between medical specialties. Its convoluted evolution was deeply affected by the rapid expansion of the sciences in the 19th century. This did not always result in immediate changes to medical practices: there is often a lag between advances in basic science and changes in clinical practice, as progress in science first changes the conceptual background and medical understanding before impact on clinical practices emerges. Thus Harvey's discovery of the circulation of the blood in 1628 had no short-term beneficial effects on medical practice. Until the late nineteenth century, the application of scientific knowledge to medicine spawned quackery as often as genuine medical progress (Bearn, 1977).

> There was no convincing evidence, in the early part of the [nineteenth] century, that the physician trained in science had better results than the older physicians who were not thus trained (…). It was not at all obvious that a knowledge of, say, chemistry, enabled a nineteenth century physician to provide better health care (…). Medical science (…) had not as yet become translated into convincing practical results. There was no good evidence that long and expensive training in the medical sciences was the sole means of making effective doctors (King, 1982).

To use Ryle's (1949) terms, "knowing that" or *declarative knowledge* is different from "knowing how" or *procedural knowledge*. The latter does not necessarily need much of the former, and the former can be learned without having any effect on the latter. In the United States the reforms in medical education and training fostered by Abraham Flexner and William Osler, under French and German influence, strengthened the scientific elements in the knowledge-base provided for medical students but it was combined with hands-on clinical experience. Indeed, there was no good reason for doctors to increase their faith in science until it could be shown that such reliance would lead to better patient care.

> Faith in science (…) was not widely shared until the end of the nineteenth century, when scientists were first able to make an overwhelmingly convincing case (…) for the connection between scientific theory and research and utilitarian technological applications (Larson, 1984).

Whilst it is indisputable that advances in the basic sciences, such as molecular biology and pharmacology, have an impact on medical practice, it was not to the basic natural sciences as such that the changes in clinical practice at the end of the nineteenth century should be attributed, but rather to the emergence of clinical research and clinical sciences – the investigation of the symptoms and causes of disease and the development and application of therapeutic interventions – which created the crucial mediator between basic science and professional practice.

> The rapid rise in America's accomplishments in clinical science in the early 1900s can be attributed to the effort of a small group of men who created specialised, rapidly expanding positions and faculties for clinical research (…). There soon emerged the middleman of medical science – the full-time clinical investigator – who formed the bridge between the basic scientists on the one side and the practitioner of medicine on the other (Harvey, 1981).

In the preparation of secondary school teachers, the knowledge-base was taken to be their subject knowledge, or knowledge acquired through a university degree in the subject of the school curriculum they intended to teach. Such graduates have been permitted direct entry to school teaching without any teacher training, on the assumption that the art of teaching required no special knowledge at all, but simply experience. Knowing one's subject is a necessary but not sufficient condition for effective teaching, which also requires the acquisition of what has been called *pedagogical content knowledge* (Shulman, 1986), or the knowledge about how to structure the teaching of the subject so that students learn – which concepts are easy or difficult for students, which parts are better taught before others, how teaching relates to the teacher's understanding of what students already know, and so on. Various components of the teacher's knowledge-base has been suggested (*e.g.* Reynolds, 1989; Dill, 1990; Hargreaves, 1993; Turner-Bisset, 1999), but how they relate to one another and how they are acquired remains deeply obscure – which is also true of doctors and engineers (*Cf.* Carlsson, 1999).

Since, however, belief in progress and the authority of science developed together and were mutually reinforcing, not least in the field of medicine, it is not surprising that a knowledge-base for teaching should also have been sought within the rapidly developing social sciences, especially if modelled on the natural sciences.

> American social scientists are interesting because their faith in science as the engine of progress has been especially intense. From the outset they claimed to have established sciences before they were in possession of any body of scientific knowledge (Ross, 1984).

Oblivious of this last observation, but keen to provide the teaching profession with a stronger knowledge-base, those involved in teacher training turned to psychology, and later to sociology, for the facts, theories and concepts of basic social science which could be applied to educational phenomena, especially those of the schoolroom. And the legitimizing function of the social sciences assumed particular importance in the 1960s when in the United Kingdom the decision was taken that teaching should become an all-graduate profession and that primary school teachers should have a Bachelor of Education degree to match the Bachelor of Arts or Bachelor of Science of the secondary school teacher. Thus topics such as child development and the psychology of learning moved to the centre of the curriculum for initial teacher training.

Today it has to be conceded that the original promise of the social sciences was not delivered to education. Within a mere twenty years of the establishment of the BEd., confidence in the social sciences as the source of a professional knowledge-base had eroded, both among practising teachers and among politicians and critics of teacher training, though not among the teacher trainers. With the intervention of UK ministers of education in teacher training from 1984 onwards, the social sciences were progressively demoted and are today marginalised within teacher training.

The failure of the social sciences to generate a knowledge-base for teachers is explained largely by the inability to develop a persuasive educational equivalent to clinical science, which would serve as a powerful bridge between basic science and professional practice in a way leading to evident improvements in professional practice.

The core of the professional knowledge-base

It has been argued by Abbott (1988) that *all* professions (by definition providing a service to clients) have common features which, adopting an openly medical metaphor, he calls diagnosis, inference and treatment.

> Diagnosis and treatment are mediating acts: diagnosis takes information into the professional knowledge system and treatment brings instructions back out from it (...). Inference (...) takes the information of diagnosis and indicates a range of treatments with their predicted outcomes.

These concepts are as readily applied to what teachers do for students as to what physicians do for patients. Diagnosis has two elements. The first, *colligation*, consists of a set of rules deciding what kinds of evidence are relevant and valid in making a diagnosis. The second, *classification*, names the diagnosis by placing it within a dictionary of professionally legitimate problems. In short, clients present a problem of some kind – what kind of illness a is this? why is this child having difficulty learning this? – and the professional draws upon rules to decide if it really is a medical (or educational) problem, and exactly what *kind* of problem this is and how it is to be named.

The systems of colligation and classification apply also to the treatment: there are rules for deciding what treatments, which have their own system of classification, are relevant to the problem and which shall be chosen. The inference process – which I think is more appropriately classed as *professional judgement* – links diagnosis and treatment so that, wherever possible, the treatment is likely to resolve the diagnosed problem.

Within professions, colligation and classification systems betray their evolutionary origins and do not necessarily reflect an abstract, academic system of ordering diagnosis and treatment. In medicine, for instance, diagnostic systems may be based on pathology (muscular atrophy) symptoms (neuralgia) aetiology (amoebic dysentery) or the discoverer (Paget's disease) or a combination (P*aget's disease* becomes

osteitis deformans). In education, the one sector which in these matters comes close to medicine is that of special educational needs or remedial education, where there is an evident influence from clinical psychology as well as a more explicit concept and process of both diagnosis ("What are this child's learning needs and what is affecting them?") and treatment ("What treatment is available to remove or mitigate the problem?").

In both education and medicine, I suggest, the classification systems for diagnosis, which is at the core of the professional knowledge-base, contains three dimensions:

– How common or rare is the problem?

– How major or minor is the problem?

– How easy (or cheap) or difficult (or expensive) is it to treat the problem?

Within both professions, problems arise in all possible combinations of these dimensions. At one extreme there are common, minor problems that are easy to treat – a minor cut, talking out of turn in the classroom – and at the other are the rare, major problems that are difficult to treat – Creutzfeldt-Jacob disease, an emotionally disturbed child with severe learning difficulties. Mastering these three dimensions of the core of the knowledge-base is the essence of professional learning and takes time and experience.

In medicine, to achieve high status one must be a demonstrably able practitioner with a high degree of mastery of the core knowledge-base. In their thirties, doctors often see themselves as overloaded with their formal knowledge-base and seek wider experience to strengthen their clinical know-how and professional judgement. A decade later, they return to their formal knowledge-base, feeling a need to keep up-to-date across the rapidly expanding state of formal knowledge in medicine. Doctors who diverge into administrative or academic roles risk losing their credibility among practitioners. Schoolteachers, after ten years' experience, put less emphasis on extending their formal knowledge-base, and seek opportunities for *reflection* about their experience. Although there is the same risk of loss of credibility to those abandoning full-time, front-line practice, there are relatively poor promotion prospects for classroom teachers. For higher status and pay, a teacher enters an alternative career path of manager, inspector, teacher trainer or administrator. Even mainline promotion to headteacher requires mastery of a different knowledge-base, as the recent introduction in the United Kingdom of the mandatory qualification for headship illustrates. By contrast, medicine announces clearly to all – including trainees – that continuing mastery and development of the practitioner knowledge-base is the principal source of prestige and promotion within the profession.

In some respects, devising systems of classification for both diagnosis and treatment is difficult for teachers, since they are not as heavily focused on the individual as is true in most medicine. Teachers routinely deal not with the individual child, but with the individual in the social context of the classroom, and also with the class as a whole: at the core of teaching is the skill of managing classrooms, not just individual students. Diagnosis and treatment are thus socially embedded in ways that are unusual in medical fields. In addition, in deciding a treatment for a learner the teacher has to decide not merely *what* to give the child (*e.g.* some curriculum content) but also *how* to do so (that is, a pedagogic strategy), for children are, one suspects, far more variable in their response to their teacher's treatment than are patients to their doctor's. Moreover, whereas most professionals, on first meeting their client, expect to focus immediately on addressing the client's problem and excluding material that is irrelevant to its diagnosis and treatment, school teachers will (unlike most teachers in higher education) want to focus on "the whole child" and his or her wider development, rather than merely on the immediate problems at hand. So medical systems of classification for both diagnosis and treatment are, in contrast to their equivalents among school teachers:

– More restricted in scope.

– More explicit and clear.

– More consensual among practitioners.

– More related to, or grounded in, science.

– More essential for effective practice.

Given the complexity of both diagnosis and treatment in education, it is arguably even more important for teachers than for doctors that they should have explicit and consensual classificatory schemes of diagnosis and treatment in order to generate a smoother and speedier methods of acquisition by novices of this part of the knowledge-base. Greater agreement on classificatory schemes might generate more focused research and text-books on teaching. Social science may well claim to be able to improve classification systems for the diagnosis and treatment of educational problems, and thus to furnish teachers with a powerful professional knowledge-base, but for the most part such conceptual schemes, only superficially and temporarily internalised, are largely abandoned, leaving residual traces, as novices quit their formal training and set about building up their professional knowledge-base through personal experience.

So social science has thus far failed to generate for teachers either professionally acceptable classificatory schemes or (as was once the case in medicine) to sophisticate pre-scientific schemes in existing professional practice. Teachers in regular classrooms in effect develop their own personalized classification systems and rules of evidence.

> Teaching has not been subjected to the sustained, empirical and practice-oriented inquiry into problems and alternatives which we find in university-based professions. It has been permitted to remain evanescent; there is no equivalent to the recording found in surgical cases, law cases and physical models of engineering and architectural achievement. Such records, coupled with commentaries and critiques of highly trained professors, allow new generations to pick up where earlier ones finished (…). [T]o an astonishing degree the beginner in teaching must start afresh, uninformed about prior solutions and alternative approaches to recurring practical problems What student teachers learn about teaching, then, is intuitive and imitative rather than explicit and analytical; it is based on individual personalities rather than pedagogical principles (…). One's personal predispositions are not only relevant but, in fact, stand at the core of becoming a teacher (Lortie, 1975).

Many teachers attest to the truth of such claims. New teachers gain much from informal socialization among experienced teachers, where there exists a professional common-sense knowledge that is not codified but works as a basis for professional use and for dialogue with colleagues such as a "difficult child" or a "learning difficulty". If the level of the language seems largely common-sensical, this is perhaps because

> (…) one of the most notable features of teacher talk is the absence of a technical vocabulary. Unlike professional encounters between doctors, lawyers, garage mechanics and astrophysicists, when teachers talk together any reasonably intelligent adult can listen in and comprehend what is being said (…) [and] the uninitiated listener (…) is unlikely [to] encounter many words that he has never heard before or even any with a specialized meaning (Jackson, 1968).

Because the development of a knowledge-base for teachers was supposed to proceed in linear fashion from the social sciences to application in educational contexts, teachers' professional or craft knowledge in use was not seen as itself worthy of serious study or formal codification. Indeed, it is arguable that the strong position that social science came to play within educational studies in the 1960s actually impeded the study and codification of teachers' craft knowledge (McNamara and Desforges 1978; Brown and McIntyre, 1993), even though here was a potential contributor to a knowledge-base.

There is, of course, a tension in all professions between codified professional knowledge and professional knowledge in use.

> The character of the abstract classification system is dictated by its custodians, the academics, whose criteria are not practical clarity and efficacy, but logical consistency and rationality. Professional knowledge consists, in academia, in a peculiarly disassembled state that prevents its use (…). The prestige [of a profession] reflects the public's mistaken belief that abstract professional knowledge is continuous with practical professional knowledge and hence that prestigious professional knowledge implies effective professional work. In fact, the true use of academic professional knowledge is less practical than symbolic (Abbott, 1988).

In medicine, novice doctors experience difficulty in transferring what they have learned from text-books or lectures into usable knowledge that they can deploy in relation to the case at hand, for diagnosis

and/or treatment. For novice teachers, by contrast, practical problems in classrooms are not usually perceived to be solvable by drawing upon the psychology of education or child development, that have been studied in the university-based initial training. On the other hand, teachers pay a heavy price in that the decisions they make about children are always open to question and challenge because there is no strong, science-based body of knowledge to legitimize such decisions. Clinical decisions made by doctors may not be grounded in science or scientific evidence, yet because the medical enterprise is perceived by the public to be more strongly grounded in science than it is, the decisions are legitimized as if they *were* firmly grounded in science.

Nevertheless, rising public expectations of both professions have given birth to demands for greater accountability, which in turn have fuelled more specific demands, for instance in terms of what diagnostic procedures or specific treatments patients want from their doctor, or in terms of the curriculum content or levels of achievement that parents demand of teachers for their children. And in many countries politicians have sided with the consumers rather than the professionals. A significant knowledge gap between doctors and their patients remains, of course, but this is to some degree eroded by the public interest in medicine, an appetite fed by newspaper and magazine articles promoting health and by television series about life in hospitals which diffuse knowledge of medical terminology and practices. Though much doctor-doctor talk seems initially incomprehensible (as in ER, the popular American television series), if the gap is to be closed it is seen to be the responsibility of lay-people to learn the technical language for themselves, as it is thought to be right and proper that doctors should talk *scientifically*. And in extreme cases, such as the Aids crisis in the United States, activists will master the medical knowledge-base to a degree that disconcerts and destabilizes the medical establishment (Epstein, 1996). The knowledge gap between teachers and lay people is relatively small, and where there is a gap to be closed, it is seen to be the teachers' responsibility to do so, for they are held to have a duty not to use "jargon" when everything they do as teachers could so easily be explained in less obfuscatory terms.

Professional training and the knowledge-base

The nature of the knowledge-base for both teachers and doctors is affected by the nature of their basic or initial training. Within medicine there is a split between physicians and surgeons. Physicians have always set store on their expertise being grounded intellectually in higher education and thus see the university as a natural seat of professional learning. The origins of surgeons' training lie in the apprenticeship mode of the barber-surgeons. Today, both types of doctor have a strong academic element to the knowledge-base but see its acquisition as requiring practical apprenticeship under an experienced and more expert practitioner. Nowhere is this better exemplified that in the life and influence of Sir William Osler, who made a major contribution to the nurturing of scientific medicine, yet combined this with a passionate belief that medicine could only be fully learnt on the wards with patients. As a gifted teacher he placed emphasis on

> (…) full and prolonged clinical instruction, and on the importance of bringing the student and the patient into close contact, not through the cloudy knowledge of the amphitheatre, but by means of accurate, critical knowledge of the wards (…).

and insisted that

> I desire no other epitaph (…) than the statement that I taught medical students on the wards, as I regard this as by far the most useful and important work I have been called upon to do (Osler, 1904).

Believing thus that the main purpose of the medical school was to train effective doctors, Osler fully recognized the fundamental tension in the professional knowledge-base when he observed that

> (…) the greatest difficulty in life is to make knowledge effective, to convert it into practical wisdom (quoted in Bryan, 1997).

The tension in medical education between formal training and apprenticeship persists to this day (Vang, 1994; Starr, 1982). In the United Kingdom, doctors who wished to train as a hospital specialist used to spend between ten and fourteen years after registration under the supervision of a consultant (or attending, in US parlance) before they were qualified to become a consultant. The reforms to bring the period of

such training into line with the European Union now require that the training period be reduced by half. Though there is a formal element to this training, in examinations set by the relevant Medical College, much of the training provided by the consultant is informal, practical on-the-job training in apprenticeship mode. The response of the consultants to the reduction in the post-graduate training period was to demand more time for formal teaching, whereas the juniors asked for a higher quality on-the-job training.

I have distinguished two forms of this apprenticeship, apprenticeship-by-osmosis and apprenticeship-by-coaching (Hargreaves *et al.*, 1997*a*; 1997*b*). In apprenticeship-by-osmosis the consultant leaves the responsibility for learning almost entirely to the junior doctor, who can passively absorb what can be gleaned from watching the consultant at work and who can extract explicit teaching from the consultant only by taking the initiative to do so by diplomatic means. In apprenticeship-by-coaching, the consultant accepts responsibility both for teaching and for helping the junior to assume greater responsibility for learning. Apprenticeship-by-osmosis has been a traditional pattern of postgraduate medical training, but is being replaced by apprenticeship-by-coaching.

Many doctors are ambivalent about their concept of apprenticeship and its role in the acquisition of the medical knowledge-base. They feel the idea is valuable because becoming a skilled medical practitioner requires practical, hands-on experience under the supervision of an experienced colleague, and cannot be learnt from text-books. At the same time they are conscious that the element of osmosis leaves too much to chance, which is what happened in earlier forms of initial teacher training. Retention of some form of apprenticeship model is strongly supported by theories of situated learning (Lave and Wenger, 1991), in which learning is no longer seen as something which takes place only in the mind, structurally independent of the context in which it takes place. Rather, the context and situation and the mental learning interpenetrate one another. Learning to be an effective medical practitioner is learning to *do* something, to perform in a given way, not to be able merely to talk about it. Learning, in other words, is always situated, and is most effectively acquired in the same setting as that where the learning is to be later exercised or applied.

To become a professional is, on this view, a process of becoming a full member of a *community of practice*. The novice, or junior doctor, enters the community of medical practice by participating in a peripheral way, not only by doing simple, delegated tasks and the "scut" work but also by *assisting*, or making a partial and limited contribution to the work as a partner of the full member of the community of practice, namely the consultant. Becoming a full member of a professional community is a matter both of acquiring knowledge and skills and of acquiring a relevant identity; and both professional skill and professional identity are progressively acquired by participation that becomes decreasingly peripheral over time. Novices learn not merely to talk *about* the practice of their profession, but *within* it. Learning is not merely a condition for membership of the community of doctors (or teachers), but is itself an evolving form of membership.

Such learning-through-contextualized-practice is effective in part because this is the more natural way of acquiring the *tacit* knowledge (Polanyi, 1966) that is an inherent feature of complex skills. We know more than we can say. Some knowledge is not easily expressed in words, and so is difficult to talk about (as in a lecture) or write about (as in a text-book) or to communicate from "master" to "apprentice". Some learning is more readily achieved if apprentices watch the master at work in a demonstration or modelling of the skill concerned and then try it out under guided supervision for themselves. Much of what professionals call "professional judgement" draws heavily on such tacit knowledge, as when a physician rapidly diagnoses a rare condition or selects a management option that is highly appropriate to the specific condition and circumstances of an individual patient – but in both cases may find it difficult to say how the conclusion or decision was reached. (The same applies to experienced teachers, who do not find it easy to explain how they can successfully anticipate pupil problems or can select an effective way of helping a pupil from a wide range of options in a way that seems highly opaque to the novice.) Consultants' insistence that "clinical judgement" cannot be taught, but only acquired through experience, confirms the thesis that an adequate professional training requires apprenticeship through peripheral participation in a community of practice.

The theory of situated learning thus validates and legitimizes the traditional commitment of doctors to notions of apprenticeship. Learning in the lecture room is not context-free learning, but learning-in-

the-lecture-room. The same can be said for private study. In both cases there will be problems in transposing context-of-study knowledge into a context-of-use practice. Better training for junior doctors would often be more readily achieved by more effective coaching within an on-the-job apprenticeship mode than by extra formal teaching. In the United Kingdom and in the United States – but not in Germany – craft apprenticeships declined rapidly in the twentieth century (Roberts, 1993; OECD, 1994; Lane, 1996). In the United Kingdom they have recently been revived on a small scale, which is a welcome recognition that one of the oldest and most tested forms of transmitting a knowledge-base might have some advantages over the now ubiquitous off-the-job formal training that has come to be almost synonymous with education (Hasluck *et al.*, 1997; Fuller and Unwin, 1998).

In the education and training of teachers, by striking contrast to that of engineers and doctors, the concept of apprenticeship has often been openly treated as a term of abuse for a form of teacher training which is held to be seriously and irremediably defective. Teacher training in the United Kingdom has also been reformed by government fiat. Until recently, graduates completed a year of full-time initial teacher training, two thirds of which was devoted to study in the university and one third of which was spent in schools under the supervision of a practising teacher (the "teaching practice"). In 1992 the government reversed these allocations, to the consternation of university-based teacher trainers, distressed at being instructed to transfer a portion of student teacher fees to the schools in recompense for the longer period of school-based supervision.

Prior to these reforms there was rarely a job description for the practising teachers who supervised the teaching practice, nor was any training provided for them. School-based supervisors have now been given a new name – mentors – and many books now advise on how the role should be carried out. Senior doctors with responsibilities for training junior doctors could learn much from the development of mentoring in teacher education – and they could offer something in return to the conception of the mentor. For the model of mentoring, and of how trainee teachers learn, is not, as one might expect, based upon the theories of situated learning described above. Rather, the dominant model is that of *the reflective practitioner* (Schön, 1983; 1987). Though there are many reasons to explain the appeal of this concept to teacher educators, an important one is that it legitimizes the critical scrutiny, rather than transmission, of existing professional practice. In medical postgraduate training, the supervisor of the trainee is an experienced practitioner whose role is to induct the novice into the profession and to pass on one's own knowledge and skills. In postgraduate teacher training, the university-based tutor is not a current practitioner but an academic who has sometimes regarded the mentors as a threat insofar as they may transmit obsolescent or ineffective conventional practices to trainees. In such circumstances the university-based academic is suspicious of apprenticeship and the associated notion that the mentor should offer the trainee peripheral participation in a community of (potentially dangerous or unworthy) practice. Instead the trainee should be inoculated against catching the diseases of conventional practice, and this is most easily achieved if both university-based tutor and school-based mentor adopt the reflective practitioner model which requires the trainee constantly to challenge the assumptions behind existing professional practice and to consider alternatives to them. The weakness of this position is obviously that the trainee is being expected to become critical of professional practice before much of the basic knowledge and skill has been acquired.

Research, knowledge production and the professional knowledge-base

Practising teachers who serve as mentors for trainee teachers are usually not actively engaged in educational research and development. Educational research and knowledge production in the United Kingdom is funded from various sources – national and local government, research councils, charities, business – but most of it is channelled though the universities, where academics design and execute the research. Only rarely do practising teachers play a part in the design of research programmes or receive funding to carry it out.

In medicine, by contrast, much research and knowledge production is carried out by practising doctors, rather than full-time researchers no longer working with patients. In consequence, the research agenda is heavily influenced by front-line practitioner concerns, and trainees are supervised by consult-

ant practitioners who both carry out the research and apply the results to their practice. In teacher training, the school-based mentors are very unlikely to be active researchers or applying outcomes to their practice. They provide for trainee teachers a very different model of how new knowledge is generated, disseminated and then applied to improve practice. It is in the university, rather than in the school, that the model for research is provided, but most trainee teachers will spend their lives in schools, not the university. The substantial overlap in medicine between hospital practitioners and researchers socializes young doctors to attitudes and practices that are very different from those in education where there is a sharp split between the two roles.

Among educational researchers there is a deep dispute about why educational research has relatively little impact on changing school teachers' professional practices. It is argued that the social sciences are not well placed to generate the kind of research styles or research outcomes that can directly guide professional practice and that in any event the variables affecting professional practice are much more complicated in school classrooms than in medical consulting rooms. This denial that research is likely to have much direct impact on practice thus sustains the so-called "enlightenment" view of educational research, in which the function of research is to change the climate of opinion and understanding rather than to affect the immediate concerns of policy or practice. Though obviously containing some partial truth, this view of research is easily interpreted as a discouragement of applied research which seeks to have some short-term impact on policy or practice. It also assumes that the ideas emanating from the research community are generally beneficent as they penetrate the practitioner community, whereas some of these ideas, in the United Kingdom those of Bernstein and Piaget in particular, have entered practising teachers' minds in a highly distorted form during their academic initial training, and sometimes had very negative effects on practice.

Evidence-based practice and the professional knowledge-base

The dangers of over-emphasis on the enlightenment thesis of the impact of research are particularly apparent when educational researchers are confronted with the rapid growth of *evidence-based medicine* (or EBM for short). This movement begins from a recognition that much current clinical practice is not grounded in firm evidence or a body of scientific knowledge, or is not so grounded to the extent that it could and should be.

> The fact that medical treatment is not invariably followed by clinical improvement is not one that those interested in medical quality – be they patients or doctors – can ignore (…). It is as if once a treatment has been given then medical obligation is at an end. Or, to put it another way, the outcome of treatment seems sometimes to be less important than its actuation (…). Whatever the reason, it is highly likely that a large proportion of treatments, not to say investigations and referrals, are no more than a face-saving disguise for medical impotence (Pickering, 1996).
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> Many idealistic students enter medicine in the belief that they will become "rescuers": active agents who will save the sick from untimely death. The mundane truth – most patients improve without treatment – comes later, and, for some rescuers, this humbling insight never arrives. All too often, an inflated view of medicine's prowess has led to action that is both unfair and harmful (Silverman, 1997).
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> Most physicians can remember the day when, armed with a degree, a mission, and confidence, they could set forth to heal the sick (…). Each physician was free, trusted and left alone to determine what was in the best interests of the patient (…). All of that is changing (…) one of the basic assumptions underlying the practice of medicine is being challenged. This assumption concerns the intellectual foundation of medical care. Simply put, the assumption is that whatever a physician decides is, by definition, correct. The challenge says that while many decisions no doubt are correct, many are not, and elaborate mechanisms are needed to determine which are not (Eddy, 1990).

Nor is this merely a matter of minority, self-critical medical opinion: hard evidence derives from studies of medical practice variation.

> Similar patients treated for the same diagnosis have hugely variable outcomes depending on their clinician, hospital and geographic location. This phenomenon is unnerving and largely unexplained (Eve and Hodgkin, 1997).
>
> Every clinician knows that there is indefensible diversity in the use of diagnostic methods and therapies and that there is unacceptable variation in the quality and treatment delivered by different clinical teams (Peckham, 1991).

Of course, the training of doctors probably leads them to exaggerate the significance of therapeutic intervention in terms of a nation's health and so they regard the exposure of their practice (and related knowledge-base) as not grounded in evidence as an embarrassment. And the same applies to the realisation that common surgical operations of the past, such as tonsillectomy, were fads and fashions performed on many patients without scientific or medical warrant. Nevertheless EBM is a somewhat controversial concept. To some, it is what doctors have always done, or should have been doing, all along; to others, it is a threat in that it appears to reduce the physician's clinical discretion or judgement and puts far too much faith in the conclusions drawn by researchers or reviewers of research. Its leading British advocates express the intention simply.

> It's about integrating individual clinical expertise and the best available evidence from systematic research (…). By *individual clinical expertise* we mean the proficiency and judgment that individual clinicians acquire through clinical experience and clinical practice. Increased expertise is reflected in many ways, but especially in more effective and efficient diagnosis and in the more thoughtful identification and compassionate use of individual patients' predicaments, rights and preferences in making clinical decisions about their care. By *best available external clinical evidence* we mean clinically relevant research (…) especially from patient-centred clinical research into the accuracy and precision of diagnostic tests (…) and the efficiency and safety of therapeutic, rehabilitative and preventive regiments(…). Good doctors use both individual clinical expertise and the best available evidence, and neither alone is enough. Without clinical expertise, practice risks becoming tyrannized by evidence (…). Without current best evidence, practice risks becoming rapidly out of date (Sackett *et al.*, 1996, italics added).

There is nothing here to endorse fear in the teaching community that evidence-based practice entails researchers providing practitioners with mechanistic and simplistic solutions to complex problems, nor does it endorse an "enlightenment" view of research as being restricted to some generalised, indirect enlightenment of practitioners and their understandings. Between these extremes, EBM offers a practical middle way which requires that *i*) researchers undertake the appropriate patient-centred research *ii*) which is collated and mediated to the clinician when needed and *iii*) is then taken into account by the clinician as part of the professional judgement in making diagnostic or therapeutic decisions about the individual patient with distinctive characteristics in distinctive personal and social circumstances.

It is the second of these elements, the collation and dissemination of the research findings, which is the most difficult to achieve. Most doctors subscribe to professional journals – the *British Medical Journal* and the *New England Journal of Medicine* are world famous – which enjoy some success in mediating research evidence to strengthen the knowledge-base of practitioners. (There are no equivalents for teachers.) But journals, however good, are not enough. One study (McColl *et al.*, 1998) has shown that most general medical practitioners are supportive of EBM and believe it contributes to better patient care, but experience problems in finding easy access to, and time to consult, the research or research reviews. Cheaper and more widely available information and communication technologies will soon support better dissemination at reduced costs.

An evidence-based approach in education has as much promise for improvement as it has in medicine, but costs are involved here too. As things stand, there is too little research of the kind that is relevant to practising teachers and policy makers, largely because so much research is supply-led rather than demand-led. Action needs to be taken to focus research more strongly on classroom pedagogy; and teachers and policy makers need to play a stronger role in shaping the agenda and priorities for education research. There will also be a need to foster, within a more focused educational research, experiments of various kinds, and especially randomized controlled trials, which have become the gold

standard in medicine (Maynard and Chalmers, 1997) but are exceedingly rare in education. Only from studies such as those conducted in medicine can a knowledge-base be generated that will save teacher time and energy by identifying interventions that are pointless or even harmful to pupils.

Evidence-based teaching and teacher-researchers

In some respects teachers and physicians face similar problems.

> [P]hysicians must make decisions about phenomenally complex problems, under very difficult circumstances, with very little support. They are in the impossible position of not knowing the outcomes of different actions, but having to act anyway. No one is questioning the sincerity, honesty or diligence of physicians (…) [but] physicians must have solid information about the consequences of different choices and must be able to process the information accurately. Currently we lack both the information required for decision making and the skills needed to process the information (…). The solution is (…) to improve the capacity of physicians to make better decisions (…) and we must build processes that support, not dictate, decisions (Eddy, 1990).

It is on such premisses that evidence-based medicine is built. Of the changes required to establish, or strengthen, evidence-based teaching, supporting more practising teachers in schools as researchers is among the most critical. Personal involvement in research at some stage in one's career is a key sensitizer to the value of research findings and, as in teaching hospitals, a vital element in the creation of a culture in which research is valued.

There are three main impediments to the creation of more teacher-researchers. The first is the lack of funding. Many teachers are willing to do research, and to do so in partnership with universities, but they lack the resources to pay for the substitute or additional teachers needed to release them from classroom duties. This can only be achieved by diverting to schools, and the school-based research consortia now being established in the United Kingdom, some of the research funding now in the hands of universities.

The second impediment is the failure to re-shape the profession so that teacher work in classrooms is set at a higher professional level. Doctors delegate much of their work – the minor ailments that are easy to treat, or other specialised tasks – to trainee doctors, nurses or para-medical staff. By delegating more to assistants, teachers could reserve to themselves the important educational problems that require high level skills, experience and professional judgement. This would provide space for, and the incentive to pursue, research into more effective professional practice to strengthen teachers' knowledge-base.

That many teachers lack the confidence to engage in research is a third impediment. There is now a significant pool of potential researchers among teachers, namely those who have undertaken a higher degree in education, which often includes research training and some practical research experience. With more support such teachers could continue with some research and quickly establish the principle of the teacher-researcher. Knowledge monopolies are a key source of professional power, and as in the United Kingdom the responsibility for initial teacher training has been progressively transferred to teachers in schools, the knowledge-power-base of academic teacher trainers increasingly lies in their monopoly over knowledge of how to do research. The extent to which they will allow this knowledge to be diffused to the whole profession is unclear.

Science, art and professional tinkering

The creation among teachers of more positive attitudes towards evidence-based teaching would involve changes in teachers' psychology and their professional culture. Both doctors and teachers are conscious of the artistic elements in their professional practice. Teachers often take pride in the fact that their knowledge is intensely personal, carved slowly over the years out of private (not collective) experience. Although this is less evident among doctors because of the stronger scientific base to their knowledge, they too constantly emphasize the artistic elements in their diagnostic and therapeutic decisions, relating what they know from science to the unique circumstances of the patient at hand. "Medicine", said

the American physician Oliver Wendell Holmes (1871), "is the most difficult of sciences and the most laborious of arts", and this was echoed by Sir William Osler's (1904) assertion that "The practice of medicine is an art based on science (…). For perdition inevitably awaits the mind of the practitioner (…) who has never grasped clearly the relations of science to his art, and who knows nothing, and perhaps cares less, for the limitations of either". In the same spirit, the British physician, Lord Platt (1972), defined diagnostic skill as being one "more closely allied to the skill of a connoisseur examining a picture or an old violin than it is to what we normally think of as science".

Insisting that professional practice has artistic features shores up professional autonomy, which is fiercely defended. For doctors, the right to independent clinical judgment is needed to protect them against a view that medicine's scientific knowledge-base can be applied in any narrowly technical or standardized way. For teachers, the right to work in one's classroom according to one's own lights is held to protect them against educational fashions or political incursions into pedagogy. Teachers might, however, be willing to sacrifice some of their autonomy for a better knowledge-base through evidence about "what works" in education. This might not simply make them more effective, but paradoxically it might increase their autonomy by protecting them against politicians telling them what to do, especially when ministers have no sound evidence for their prescriptions, their preferences having no greater warrant than the fads and fancies that flourish among teachers in the guise of professional knowledge. At the same time, if a treatment, especially a cost-effective one, has been shown to work, politicians might argue that all practitioners should adopt the treatment and thus attempt to over-ride professional autonomy.

Whatever science might contribute to their practice, both doctors and teachers have to exercise considerable professional judgement in making their higher-level decisions; they have to "read" both client and context and be prepared to adapt their treatment until they find something that "works" with the client, whether patient or pupil. In short, and as discussed in Chapter 3, they learn to *tinker*, searching pragmatically for acceptable solutions to problems their clients present. In other words, all professionals have to develop a craft aspect to their practice, whereby through accumulated practical experience they add to their formal knowledge-base mental schemata that provide typical solutions to typical problems presented by typical clients (Schutz, 1964) – whether it be "a difficult child in the playground who must be watched if trouble is not to start" or "an unco-operative patient in clinic who needs to be cajoled into accepting the procedure". These schemata become tacit or intuitive, until they do not work as expected, at which point the professional chooses to tinker, drawing upon the whole of the knowledge-base, in a novel way to discover something that *does* work. This tinkering is a very small scale, spontaneous and mundane way of solving minor, everyday problems of a professional's life. But sometimes this tinkering is on a grander and more formal scale, a more carefully considered and radical way of dealing with a persistent problem: it then becomes research for knowledge creation.

Tinkering is, in effect, an uncontrolled experiment and in this sense every treatment of a patient by a doctor and every treatment of a pupil by a teacher is in the nature of an experiment. If, as a consequence of tinkering, an innovative practice is successful, *i*) it is usually incorporated by the individual practitioner into an enhanced *personal* knowledge-base. To become *ii*) part of the *collective* professional knowledge-base, it has to be disseminated among colleagues and accepted by them as "good practice". It *iii*) enters the collective knowledge-base in an evidence-based form only when it is subjected to research and accepted as a verified professional practice which works. Eventually, it *iv*) enters the formal corpus of professional knowledge, especially when it can be related to formal theory and academic knowledge, and then slides back into the official professional knowledge that is transmitted to novices in their initial training.

Both doctors and teachers tinker and regularly go through steps *i*) and *ii*) with novel practices. Doctors are ahead in learning that steps *iii*) and *iv*) are an essential path to better professional practice with verifiably better outcomes for clients. Teachers share a tinkering psychology with doctors. How can they build on this foundation to create the knowledge to enrich their knowledge-base in a practitioner-led, research-based way?

Professional knowledge: from creation to institutionalization

In the short term social science is incapable of providing the greatly improved knowledge-base that teachers need. There are some promising areas, certainly, such as the neuro-sciences, but these are

largely at the "basic" rather than the "applied" level. Much of the relevant basic research, in the neurosciences and cognitive sciences, is likely to be conducted in university faculties other than education, which creates problems in the dissemination of such new knowledge into the university departments that bear responsibility for initial teacher training and the continuing professional development of teachers. While the medical school and teaching hospital have often served as the bridge between the basic sciences and clinical practice, university schools of education often have tenuous links with cognate departments. Even if cognitive psychology does, over coming decades, generate a potentially powerful knowledge-base for teachers, there is no adequate system for mediating such knowledge into the teaching profession.

In the short term we must look elsewhere for a means of strengthening teachers' knowledge-base, namely to the development of an evidence-based approach to the practice of teaching. More and better designed studies of "what works" in schools and classrooms could provide a knowledge-base, because such research can be done without necessarily finding a theoretical base for interpreting the results. In other words, the science to support education would be in terms of research *methodology derived from science*, not a substantive body of *scientific theory* as such. Indeed, if we knew much more, in relation to teachers and students in schools and classrooms, about what worked for whom under what circumstances and with what effects, this knowledge would be of real practical value to teachers, who should respond well to the notion of evidence-based teaching. At the same time educationists in universities should develop theories around such empirical findings. In medicine, too, it is not unknown for practice to be in advance of theory – anaesthesiology being a good example. In short, whereas in medicine the full-blown development of an evidence-based approach *followed* the establishment of a scientific infra-structure to its knowledge-base, in the case of education this might be reversed, with the establishment of an evidence-based approach *preceding* and actively promoting a social scientific infra-structure.

Who, then, would undertake the research on "what works?" to generate evidence-based teaching and to do so in a way that contributes more rapidly and coherently than in the past to the enhancement of teacher and school effectiveness? Some university-based researchers already contribute to this, but the majority prefer to conduct research on topics of their own choice in their own style. Without some incentive to change, I see no reason why higher education should be

> (...) prepared to extend its role from that of creator and transmitter of generalizable knowledge to that of enhancing the knowledge creation capacities of individuals and professional communities (Eraut, 1994).

And that is surely what is now needed. There is massive, innovative activity and potential locked up in the "tinkering" of teachers in their classrooms. We need to investigate and codify when and why this innovative activity does (or does not) work.

There is evidence in the United Kingdom that researchers will change their agenda when research funding is tied to particular themes, so more funding must be directed towards achieving the specific objective of enhancing the creation and dissemination of better professional knowledge and practice. One controversial move in this direction, initiated by the Teacher Training Agency in England, has been to channel research funding directly to schools, which then, in a reversal of the conventional mode, seek a partner university to assist them in carrying out the research. This could be substantially increased. Maintaining a strong tie between university-based teacher education and professional R&D has advantages.

> Cognitive commonality, however minimal, is indispensable if professionals are to coalesce into an effective group. Codification of knowledge (...) depersonalizes the ideas held about professional practice and its products. It sets up a transcendent cognitive and normative framework within which, ideally, differences in the interpretation of practice (...) can be reconciled. The formalization of the cognitive base of a profession has a powerful effect on professional unification because it allows a deeper and more thorough standardization in the production of producers than would otherwise be possible (...). Training and research increasingly depend on the same institutional structure (...). Thus in its modern sense, profession appears to be a structure which links the production of knowledge to its application in a market of services; the training institutions are the empirical arena in which the linkage is effected (Larson, 1977).

Combining the production (or creation) of knowledge with the production (or training) of the professional has over time tended to become more and more located in the university (Freidson, 1986). For this reason high status continuing professional development for experienced teachers has also been located within universities. It is no accident that declining faith in the capacity of universities to generate the knowledge-base for teachers coincides with scepticism that improving the knowledge-base of teachers is best achieved by attendance at courses outside the school. Both initial teacher training and continuing professional development are now more frequently located in the school and directed towards collective and sustained innovation and change. If the two forms of production are to be bound together, then some of the knowledge production or research must also be transferred to schools. In other words, the dislocation of knowledge production from knowledge application must be brought to an end wherever possible. Only thus can a better knowledge-base for teachers be generated, one which, because it focuses on "what works", will contribute to the current political imperative of more effective teachers in more effective schools.

More and better R&D, with the specific aim of promoting evidence-based teaching, done in partnership, provides opportunities for larger-scale, multi-site experiment undertaken by teacher-researchers working on a common topic but co-ordinated by collaborating academics. Some structural reform would help. R&D in the field of public health and health services in the United Kingdom was strengthened by the introduction of regional R&D centres with a director and support staff (Peckham, 1991; Black, 1997) and regional centres for educational R&D (Hargreaves, 1998) could provide the infrastructure for parallel developments in education.

Schools as training centres *and* research centres increasingly makes sense in that it is in both training and innovation that the *tacit* knowledge of the effective practitioner has to be made more explicit and this is a critical element in successful knowledge creation (Nonaka and Takeuchi, 1995) and transfer. This tacit knowledge of the experienced practitioner, which is so rarely drawn upon by professional researchers, is at its most refined in the middle managers of secondary schools – those who have long experience of teaching but have not moved into full managerial positions with a different knowledge-base. It is they who become the senior mentors for trainee teachers and it is they who have often taken a higher degree in education and thus obtained some experience of educational research; it is they who are potentially what Nonaka and Takeuchi call *knowledge engineers*; it is they who should be leaders of their peers coming together to share experiences, to experiment together and, when success is achieved, to engage in lateral dissemination through their networks.

All this would entail a significant re-conceptualisation of what is seen as the dissemination process, which has conventionally been portrayed as a linear, centre-to-periphery process from research in universities out to teachers in schools. Much innovation in education, unless it is mandated, does not get beyond the diffusion phase, because insufficient attention is paid to the deep problems associated with adoption, implementation and institutionalization processes in linear models (see Chapter 2). As long as we continue to believe that the most effective way of improving professional practices is "outside in", that is, produced from outside schools and then disseminated by reformers into them, then the successful adoption, implementation and institutionalization of new practices will continue to be a relatively rare phenomenon and policy makers will be frustrated by the failure of many reforms to endure and to displace poor practices. People are motivated to disseminate knowledge that they have themselves created; and there are natural, but under-used, channels for easy dissemination. If schools were more fully developed as centres of initial teacher training and research, with experienced knowledge engineers on the staff, they might "(…) actually create new knowledge and information, from the inside out, in order to redefine both problems and solutions and, in the process, to recreate their environment (Nonaka and Takeuchi, 1995)".

Schools as knowledge-producing and knowledge-mediating institutions are in their infancy, but they may well be one important route to the continuous improvement and enhanced effectiveness of schools now being demanded by politicians in many countries.

Without question doctors have been much better than teachers at advancing their professional effectiveness by combining research with practice in the interests of knowledge production. At general practitio-

ner level, however, group practices are often too small to be powerful knowledge-creating organizations. At hospital level, much of the innovative capacity is tightly locked within, and restricted to, each specialist department. Whilst new ideas and practices can be reasonably well disseminated through specialist journals and specialist medical associations, it is exceptionally difficult to diffuse evidence-based new practices *between* departments and specialties or within the *same* hospital. In this regard schools have a considerable advantage over both group practices and hospitals (though perhaps not health centres), for there is now a stronger focus on cross-departmental interaction and joint learning. In the United Kingdom, teachers speak of "whole-school policies" and "whole-school professional development" in a way that simply cannot be found in most hospitals. Schools are closer to becoming "learning organizations" than are hospitals.

A generic model of the professional knowledge-base

The above comparative analysis may, now set within the theoretical context of a generic model of the knowledge-base, be summarized as follows. Whereas the *content* of the knowledge-bases of doctors and teachers are very different indeed, the *structures* of the knowledge-bases have both similarities and dissimilarities.

The main similarity is in the structural *components* of the knowledge-base, as illustrated in the three-dimensional Figure 1. In the central, horizontal axis, four analytically distinct types of knowledge are represented:

- D*eclarative knowledge* (DEC-K), or "knowing that", which is often in a propositional and codified form.
- S*cientific knowledge* (SC-K), which is a distinctive form of codified knowledge.
- P*rocedural knowledge* (PROC-K), or "knowing how".
- P*ersonal knowledge* (PERS-K), in which through experience, including trial and error and other forms of learning-by-doing, the individual builds up and seeks to integrate a professional knowledge-base and develop expert professional judgement.

The first two kinds of knowledge are formal and largely explicit, with relatively low levels of tacitness. The latter two kinds of knowledge are rich in what is tacit. Each type of knowledge interacts with the other three types.

A second similarity lies in some shared *features* at the core of the knowledge-base and its four types of knowledge, especially the concepts of the diagnosis and treatment of clients and their problems, including how diagnoses and treatments are set with a dictionary of professionally legitimate problems (classification) and what counts as evidence for them (colligation). The acquisition of systems of classification and colligation is a key feature of professional training and socialization. Classification and colligation exemplify the dynamic interaction of the four types of knowledge.

Three dissimilarities are evident. At the pole in the upper half of Figure 1, knowledge is the unique possession of the *individual* or idiosyncratic, whereas at the opposite pole, knowledge is *social* or a collective possession of the profession. The first dissimilarity between teachers and doctors concerns the different *evolutionary paths* that have been taken by the two professions. The role of science in medicine has drawn the knowledge-base towards the social pole, whereas the lack of the science among teachers has drawn their knowledge-base towards the individual pole.

The second dissimilarity is in the form of training for the profession. Among doctors the apprenticeship model has remained strong, since both the explicit *and* the tacit aspects of the knowledge-base require effective social transmission from expert to novice. Among teachers there has been a movement away from apprenticeship towards (a version of) the "reflective practitioner" so that the social transmission of the knowledge-base, both explicit and tacit, from expert to novice is neglected and the professional socialization is further drawn towards the individual pole.

The third dissimilarity is in the approach to research and development. Again, doctors remain in the lower half of the figure, where the development of evidence-based medicine is concerned with the sharing of validated professional knowledge. Teachers, locked in the upper part of the model, engage in talk about "good practice" but have no agreed means of validating or sharing their professional practices.

Figure 1

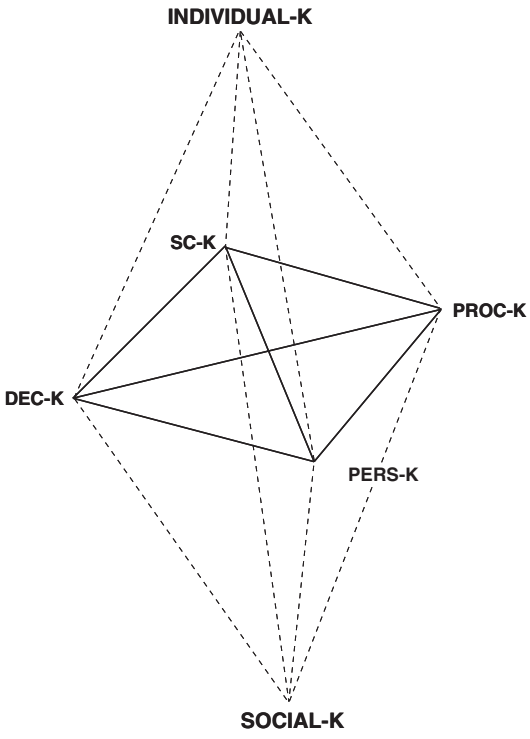


Figure 2

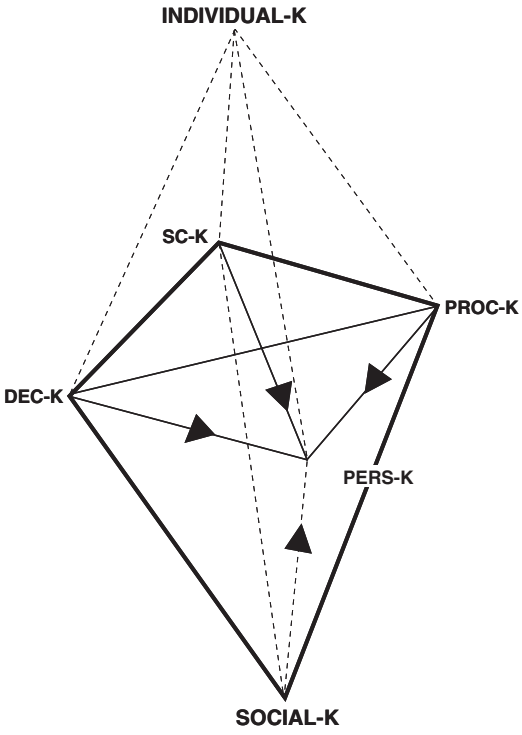
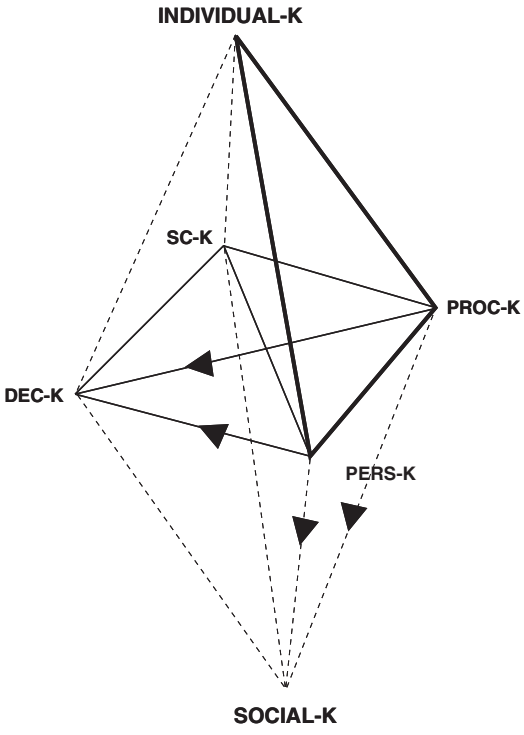


Figure 3



There is also, however, a third similarity, which is the concept of *tinkering*. In both professions this is strongly linked to personal knowledge. For doctors, it is a step not only towards better professional practice for the individual but also potentially a contribution to evidence-based and socially shared professional knowledge. For teachers, tinkering is largely interpreted as a means of developing better personal knowledge for the individual, but may be the key to the emergence of a more valid and even scientific and socially shared knowledge-base, to fill the gap left by failures in social science.

Figures 2 and 3 provide a graphical illustration of the contrasting strengths of the components of the two knowledge-bases (thicker lines). For doctors, the internal dynamic of the forces in the knowledge-base drive towards the more secure construction of the personal knowledge of each physician or surgeon, all forms of knowledge leading over time to the development of expert professional judgement. In the case of the teachers' knowledge-base, the external pressure on teachers, teacher trainers and educational researchers in many countries to improve the quality of teaching as a means of raising educational standards is now changing the internal dynamic of what has hitherto been the dominant model towards the development of a public or shared language for professional practice, since this is a prerequisite for more effective means of sharing and disseminating knowledge of professional practice that has been made explicit and subject to public validation. It remains an open question whether such changes in the teachers' knowledge-base will also include a scientific element of some kind, to which the declarative, procedural and personal components are then linked.

Conclusion

These potential changes in the knowledge-base of teachers can be understood within a wider theoretical framework for understanding knowledge production. Seen in this light, the educational reforms in the United Kingdom, such as school-based initial teacher training, school-based research, evidence-based professional practice and a renewed focus on teachers' classroom effectiveness, can be interpreted as part of the deeper social changes by which many kinds of knowledge production are moving from what Gibbons *et al.* (1994) call Mode 1 – pure, disciplinary, homogeneous, expert-led, supply-driven, hierarchical, peer-reviewed, university-based – towards Mode 2 – applied, problem-focused, trans-disciplinary, heterogeneous, hybrid, demand-driven, entrepreneurial, accountability-tested, embedded in networks. Across many spheres of knowledge production there is said to be a general movement away from Mode 1 towards Mode 2; education is unlikely to remain exempt from these changes. My concluding hypothesis is that in the United Kingdom this rapidly growing movement within education towards Mode 2 will soon put United Kingdom education at the leading edge of educational knowledge production. Since the universities are the institutions where the transition from Mode 1 to Mode 2 can be particularly painful, the bitter opposition of the university-based teacher trainers to recent reforms may simply confirm that this process is indeed under way, probably irreversibly. It will need courage for university-based educationists to adapt to the new role they have to play if Mode 2 educational knowledge production is to be successful.

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