MEASURING KNOWLEDGE IN LEARNING ECONOMIES AND SOCIETIES

Draft report on Washington Forum, organised jointly by the National Science Foundation and the Centre for Educational Research and Innovation, OECD, 17-18 May 1999

Can knowledge be measured? This forum confirmed that the answer is: “At best, imperfectly”. While knowledge is now recognised as a key factor of economic production alongside land, labour and capital, it differs in a number of ways from these more tangible factors. The impossibility of obtaining an aggregate estimate of knowledge inputs is not merely a technical matter of measurement, but also arises from the character of knowledge itself. In particular, knowledge is extremely heterogeneous in nature, and its value is not intrinsic but depends on its relationship to the user, so it cannot be quantified in the same terms as physical objects such as land or industrial capital.

Yet this does not mean that indicators of the production, stock or application of knowledge in particular sectors are useless to economists or to others seeking to improve the effectiveness of knowledge production, mediation and use. Viewed appropriately, they can produce useful perspectives. But only if there is clarity about why and how knowledge can be important, rather than a desire to stockpile knowledge for its own sake. In this context, the Washington forum brought eighteen months of CERI discussions on this subject full circle, to return to the basic question of what a sector such as education can learn by observing how knowledge is produced elsewhere. The event helped bring together some of the rich insights that have arisen from this enterprise.

As the papers to the forum make clear, it is difficult to sum up briefly the wide range of observations about knowledge and about education that have been put forward. The present report does not venture to do so (the themes are being brought together in the CERI overview report entitled “Unlocking Knowledge in the Learning Society”), but rather reflects on three key points of understanding and one key point of difference that emerged at the Washington meeting. These were:

1. An acceptance that knowledge is heterogeneous in a number of dimensions, and therefore needs to be aggregated and compared only with caution.

2. An emphasis on the relational character of knowledge, and therefore the importance of observing it in terms of the people who hold it rather than as an independent entity.

3. A recognition of the importance of the context in which knowledge is mediated - in terms for example of the character of institutions and the ways in which they learn -yet also of the difficulty in developing indicators of such factors.

4. An emerging understanding that it is importance to interpret measurement of knowledge in the context of why one desires it, and that one should not value knowledge only in proportion to that which can be measured.

5. A notable lack of consensus about the potential for using knowledge to improve greatly the performance of the education sector.
1. The heterogeneity of knowledge

The diversity of the knowledge base creates two interlocking problems when it comes to assembling indicators of the knowledge economy. One is that indicators themselves are expressed in a wide variety of ways – how is it possible to compare or aggregate, for example, the quantity of money spent on scientific or technical research and the quantity of professional contacts or networks representing diffusion of practical know-how? A closely related problem is the heterogeneity of the knowledge base itself. Different forms of knowledge are used in different ways in various sectors, sometimes as a result of inherent sectoral differences. So how can one sensibly use indicators to make comparisons?

CERI’s study on the knowledge production, mediation and use has developed some rich tools for classifying different types of knowledge, along various dimensions. Scientific, explicit, declarative and theoretical knowledge is relatively easy to measure; personal know-how, tacit and practical knowledge less so. A recurring theme of the discussion has been the importance to production and innovation of less codified and more personalised understanding. While this makes measurement difficult across the board, an additional complication is that the relative importance of, say, tacit and codified knowledge varies from one field to another. So even comparisons of the prevalence of a particular type of knowledge across different sectors need to be interpreted with caution, because this type may not have the same intrinsic importance in all situations.

Nevertheless, some commonalities were identified.

In every sector, there is a need to have effective means of accumulating knowledge, and this process can be relatively straightforwardly measured through research and development activity.

Harder to measure, but no less important, are mechanisms for access and attention. Mediation processes need not just to allow users and decision-makers to access knowledge created by others, but also to bring to their attention those aspects of a large knowledge base that are most relevant for taking decisions. This particularly applies to the information available to public policy makers, but also to busy practitioners who cannot be expected to keep pace with all aspects of knowledge that is evolving at an unprecedented pace. Indicators of knowledge accessibility depend on qualitative observations of for example the dispersion of the knowledge base.

A further feature of universal importance is the capacity for or rate of innovation. While this might be estimated in a manufacturing industry via the number of new products brought to market, or the number of people not directly involved in production, it can be difficult to translate such measures into say a public sector service industry. A related factor, which translates imperfectly across sectors, is competition. One assumption made by some participants in the forum was that a competitive environment is a spur to innovation and therefore to knowledge production. But in some cases it may on the contrary be an environment of collaboration that allows ideas to be shared and developed. Networking and collaboration can of course take place in a competitive environment, as the experience of Silicon Valley has shown. But especially in the public sector, it is by no means clear that an optimum level of knowledge advancement will always be obtained by giving individual agents incentives to outperform their “rivals”.

What in practice can be learned by intersectoral comparisons that have revealed as many contrasts as parallels? At best, the discussions organised by CERI have helped each sector to think about its own characteristics through a more generic prism than before.

One source of reflection has been the influence of the degree of codification of knowledge on the style in which it is produced and transmitted. Engineering has been characterised as a sector in which a high degree of codification greatly shortens the distance between scientific frontiers and best industrial practice, with many research-taking places within individual firms. Knowledge of education in contrast is poorly
codified, and the distance between pure research and practice is greater, with the latter depending largely on personal knowledge and practitioner networks as a substitute for scientifically derived evidence.

Understanding such a difference is useful not just for explaining why processes are different in these two sectors, but also in considering the potential for new ways of doing things. For those who would like education to make better use of research knowledge, it is useful to understand that a linear process of technology transfer from basic researchers in universities to practitioners on the ground is not the prevailing model. For engineers, many of the most important breakthroughs have been generated within companies. For biotechnologists, the dissemination of knowledge has been as much via the movement of people as through the transfer of ideas. In healthcare, it is often the users of technologies such as pharmaceutical companies that communicate knowledge to practitioners. While the education sector will not precisely imitate any of these models, because of its particular characteristics, it is helpful to understand the types of driver that help facilitate knowledge flows.

Other insights that arose from observing these sectors included:

- The importance of knowledge systems rather than individual processes. As described in the paper on engineering, for example, it is the interaction of elements such as management competence, manufacturing competence and industrial design competence that determine whether the creation and use of knowledge within an individual country is effective. This makes it risky to look at any particular indicator of the knowledge economy in isolation. Certainly the production of learned journal articles will not be effective without strong systems for mediating the knowledge that is generated. And the existence of knowledge networks will not lead to innovation unless organisations are managed in a way that allows individuals to bring new ideas to fruition.

- The uneven character of know-how, both within and between sectors. In medicine, for example, for some techniques best practice can be so well defined that it is possible to sue for negligence if it is not adhered to, while in others knowledge is far less well developed. There is also a distinction between know-how that is embodied in physical competencies (the surgeon’s hands), in the correct use of equipment, in the understanding of scientific principles and in the ability to recollect one’s own prior experience (“episodic” knowledge). A recognition of the potential importance for example of episodic knowledge as a contributor to professional know-how could be an important influence on the management, in-service training and deployment of workers with varying levels of experience.

- The varying ways, in which knowledge evolves, including within individual sectors. It was pointed out that some inventions such as the radio have evolved largely from pure science, whereas others such as the semi-conductor have evolved in a more “stumbling” manner through the interaction of research and practice. The non-linear ways in which knowledge is advanced even in technical fields such as engineering serves as a useful counterbalance to the paradigm of “laboratory based basic research”. In social policy fields in particular, where the scope for controlled experiments in the laboratory is highly limited, it is useful to regard knowledge development largely in terms of an interaction between practitioners and researchers, with the former sometimes taking on some characteristics of the latter.

2. Knowledge is in the mind of the beholder

I am the master, my name is Jowett
If it’s knowledge, then I know it
I am the master of this college
What I don’t know…isn’t knowledge

Benjamin Jowett, Master of Balliol College Oxford
It has become very clear in CERI’s discussions about the knowledge economy that unlike, say, a piece of industrial machinery, knowledge derives its character and very existence from the people who hold and use it. At a very basic level, as Jowett demonstrated, every individual has their own definition of what is worth knowing. When it comes to applications, the forum noted in particular two ways in which knowledge can be person-specific. First, by residing in the situation and tacit understanding of individuals who use it, and second, by depending on individuals to disseminate it.

“Sticky” knowledge is defined as know-how or competence that cannot be separated from the person or organisation containing it. Where potential users of innovative techniques or processes have a high level of sticky knowledge, they have an interest in participating heavily in such innovation. This principle has had an important effect on the relationship between users and product developers. In the information technology sector, for example, advanced users are increasingly taking the lead in creating applications that best suit their own specific and hard-to-codify needs. In medicine, it has been observed that about half of the uses of prescription drugs are not those specified on the label, but rather those that doctors believe will work on the basis of their experience.

This raises two big questions for any sector: how sticky is knowledge, and how can we identify what is or is not sticky? In free markets where industrial or professional users of products are the clients of product developers, there is an extent to which these questions are answered through practice. The more that clients know what they want, the more they will participate in developing new products and processes. Yet this assumes an equal relationship between user and knowledge producer, which may not be the case for say a small computer supplier buying from a large software developer, still less for a general medical practitioner relative to a drug company or a teacher relative to a university education department. So it is worth addressing explicitly the question of how much of a role a user of knowledge should be playing in its development. The fact that in some commercial relationships practitioners with high levels of tacit knowledge choose to play this role helps establish the principle that pure “knowledge producers” do not always know best.

The second way in which the embodiment of knowledge in individuals is particularly important concerns the ways in which it is mediated and transmitted. Here, knowledge workers play the role of the bumblebee: by moving from university to industry or from one company to another, they help to cross-pollinate knowledge that may not easily be blown through the air or even down fibre-optic cables.

In a previous forum, it was suggested that the most important contribution of the university to the knowledge economy was not in producing scientific breakthroughs that could be transferred to industrial applications, but in training knowledge workers. In the present forum, it was observed that in the biotechnology sector a key economic driver is the skills, knowledge, problem solving, and adaptability of highly trained personnel, who are also highly mobile. In particular, often small biotech companies rely heavily on workers with recent experience in research institutions. In this very special case, rapidly developing science and technology are brought to market as a result of this individual mobility. The characteristics of the biotechnology industry, it was agreed, are probably symptomatic of a very young industrial process. Yet they also illustrate more generally the potential for the movement of people to support technology transfer. Thus information on personnel characteristics is necessarily an important feature of sectoral indicators of the knowledge economy.

3) The institutional context and learning cultures

In his background paper on “Characterising the Knowledge Base: Available and Missing Indicators”, Professor Dominique Foray aims to develop an analytical framework and a set of indicators for casting light on the transformation of knowledge bases in various economic sectors. Professor Foray uses a series of descriptors, essential parameters and indicators to describe sectorial knowledge bases. Several participants acknowledged his framework as very interesting and a good tool for analysing the
measurement of knowledge processes in sectors. This approach to measure knowledge is holistic and ambitious.

Commentators on Foray’s paper agreed on the importance of such an approach, but cast some doubt on the extent to which one can conceive of indicators that compare their presence across sectors. The whole process of mediation, for example, can depend on different contextual factors from one industry to another. It was argued, for example, that the absence of an obvious corps of knowledge mediators in the education sector might not matter if people wearing other hats – such as teacher trainers – effectively take on the mediating role. This does not mean that descriptions of how professional and organisational learning takes place in individual sectors should not be attempted, but that comparisons across sectors need to take into account of fundamental differences from one sector to another.

An interesting example of such heterogeneity of context relates to the proposed indicator on experimental learning. It is acknowledged that much knowledge generation comes from the personal experience of practitioners, often through their own trialling of various techniques. Yet such experimentation is bound to play different roles in the contexts of different sectors. For example the highly focused (and applied) nature of R&D in the engineering industries makes it more likely for new discoveries to take place in business firms than in universities. In biotechnology, by contrast, the opposite is true: the highly scientific nature of the discovery process favours location in the universities or other entities (research institutes or technology-based start-ups) rather than in the well-established business firms. In medicine, all doctors are involved in a large amount of learning by trial and error, yet some forms of experimentation cannot be carried out other than in a laboratory. In education, the degree to which classroom teachers should be at the cutting edge of innovation remains highly controversial.

4) Asking why

Knowledge is progress. Progress is good. Therefore knowledge is good, and more knowledge is better.

This implied reasoning provides a justification for seeking indicators of the knowledge economy, and thinking of ways in which revealed knowledge shortfalls can be remedied. But in the present forum, some reservations were expressed about whether the above assumptions were always correct and in particular about whether the use of indicators could distort the search for knowledge away from what is really desirable.

The first and most obvious reservation corresponds to an underlying conclusion of CERI’s discussions about the knowledge economy: that not all knowledge is equally productive. It is of no practical value to accumulate knowledge that is impossible to use or to access. One of the problems for present day practitioners is that there is too much knowledge to make sense of. These self-evident observations must be constantly borne in mind when looking at quantities of research and development spending. If (as studies appear to show) only a tiny fraction of research in say health or education contains truly valid information that is usable for practitioners, then comparisons with how much is spent on R&D across sectors must be of limited value.

But it is not just that not all knowledge creation has got productive potential; some of it may have undesired effects. The fathers of the atom bomb sometimes wished they had never invented it. While there may not today be many scientists with this view about their own work, their numbers may grow as the potential for transforming the world in questionable directions, for example through interference with genetic processes, increases. Some scientists and social commentators would say that increasing knowledge is never bad, since man has the ability to choose what he does with it. Others, observing how much harder it is becoming to regulate uses, as dissemination through the unregulated world of the Internet becomes the norm, are not so sure.
There is a need moreover to be cautious about whether certain indicators that purport to be about knowledge creation are actually about knowledge restriction. The example was given of a large bio-tech company taking out pre-emptive patents – to prevent others from developing new techniques rather than to protect a genuine innovation of its own.

A further issue was whether innovation necessarily feeds through to the benefit of society, or whether it simply benefits the industry concerned. In the computer industry, for example, it was postulated (as a caricature) that every time hardware is manufactured more productively, in terms for example of fewer dollars per gigabytes, the benefit is counteracted by the “bloat” in software manufacture, with programmes requiring ever greater capacity. (The net result is that one’s computer becomes obsolete every two years because it is too small to run current software – a benefit to both hardware and software manufacturers but not to consumers.)

Even where new and useful knowledge is created, it was pointed out, the benefits need to be measured against the cost of producing it.

But the most fundamental danger was that the development of knowledge might be valued only or primarily where it can be quantified or at least described. A good example is education, where there is a risk that teaching focuses increasingly on tangible aspects of both process and outcome. It is possible to describe some characteristics of good teachers. But an inspection system that tries to validate every detail of the teaching process against standard template risks destroying some of the intangible features that help teachers to inspire students, and also to prevent them from taking risks and being innovative. Measurement of student outcomes only through standardised tests can similarly distort what is learned.

A widely shared conclusion was that measurement is useful only to the extent to which it contributes to genuine understanding. This requires exploration of a broad range of characteristics of knowledge systems, not all of which can be quantified.

5) Education under fire (again)

An underlying question of these CERI discussions has been whether the education sector can produce, disseminate and use knowledge in ways that help transform its productivity. Education systems have often been under fire from policy-makers and others for failing to improve their performance; educational researchers for failing to provide practitioners with the tools to do so. At the present forum the criticism came in a somewhat different form – that of scepticism (from some quarters) about whether educational research and knowledge could ever produce the required solutions, since it is impossible to carry out educational research in a laboratory that replicates sufficiently the complex and context-specific conditions of the classrooms in which innovation has to be applied.

While no consensus emerged about the degree to which education could realistically pursue an improved “production function”, this challenge helped bring out some of the conditions that would need to be present for it to do so. The first and most important is that a greater proportion of research would need to be scientifically validated and made more relevant for practice. A current investigation by the United States government has so far identified just 400 out of 20,000 academic papers that even potentially have practical applications, i.e. just 2% of the total. The fact that the number of medical papers that were both scientifically robust and clinically relevant had been estimated at only 3% was more surprising but not much consolation.

Yet both at the political and the practitioner level, there remains a strong desire to base educational research on good evidence. The danger is that if good evidence is not available, bad evidence will be used. So there is a strong case for introducing more rigorous means of validating, classifying and reporting knowledge in ways that are better established in fields depending on the natural sciences.
An important element of this is the way in which the knowledge that does exist is classified and accessed. In health care, comprehensive taxonomies are being developed that can help practitioners find their way more quickly too reliable research evidence. In education, there is not even a common way of describing and classifying problems and solutions, let alone a good route map to valid findings, although the ERIC system provides some guidance.

Perhaps a more fundamental issue, though, is how evidence about education can be improved in terms of reliability, thoroughness and accessibility in light of the observed nature of knowledge in this sector. As discussed above, “scientifically” derived evidence based on controlled experimentation is less likely to be relevant in education than knowledge based on the experiences of individuals, organisations and networks. So the big challenge to educational practitioners and researchers is to find ways of developing and disseminating this information - to create effective knowledge systems – rather than to try to emulate disciplines that are more amenable to pure science. Perhaps the most difficult part of this process is validation.

**Conclusion: towards a deeper understanding**

The bringing together of different academic disciplines and people with knowledge of different sectors of the economy has created a productive dialogue about the position of today’s knowledge economies. At best, economists are starting to analyse the complexity of knowledge rather than looking at it as a homogeneous variable whose economic value needs to be measured, while cognitive scientists address the multiple applications of knowledge rather than merely analysing its complexity and assuming its usefulness. If so, there is much that each discipline can learn from the other.

This collaboration has so far, in CERI’s forums, produced some useful and wide-ranging if rather general insights. But how can these new understandings be brought forward into future work?

The first conclusion is that cross-disciplinary understanding can create a new way of looking at indicators and innovation systems. To implement the broader view in empirical research calls for a team with a broader set of expertise than what normally has been gathered around innovation studies. Experts on education, labour market and organisational issues have to be combined with innovation experts in order to cover the whole range of indicators and systems. Professor Bengt-Åke Lundvall suggests various ways in which both the science/technology/industry indicators and the educational and labour indicators produced cross-nationally through the OECD can be broadened to take in a cross-disciplinary perspective.

Professor Lundvall emphasised that it should be carried out only as part of an exercise that seeks to improve understanding of learning systems, and not just crude numbers. In particular, the case-study approach, focusing on particular sectors and learning systems in individual countries, was seen as a fruitful way of developing a qualitative understanding that would help make sense of quantitative measures.

A second related conclusion was that national and local institutions and institutional cultures do matter. What makes the human resources development systems of some countries work better than others, for example, is often a matter of local practice such as the degree to which companies carry out their own training and research, rather than simply the overall volume of resources invested. The OECD’s ability to describe and understand specific local systems of learning and innovation is therefore likely to be at least as important in future as its ability to assemble numbers.

A third conclusion by Professor David Hargreaves is that within individual sectors there is scope for pursuing the investigation of knowledge management and what makes it effective. It is now widely accepted that for an individual student, reflection on learning processes can improve the quality of learning itself. The same may apply to organisations and to sectors: an analysis of what constitutes one’s knowledge base, and of how it can be most effectively developed, disseminated and accessed, may be a precondition
to using knowledge more productively. The present project and the publication due to come out of it have
given some tools that allow people working in one sector to see these issues more clearly in relation to
others.

The science of describing, understanding and measuring knowledge will always be an imperfect one. The
knowledge identified in this forum turned out to be capricious: sometimes sticky, often slippery, rarely
tangible, frequently tacit, and extremely heterogeneous. Yet CERI’s four knowledge forums have
assembled a wide range of leading figures - ranging from authorities on health and educational research to
organisational theorists, to a Nobel prize-winning economist, to the father of Silicon Valley – all of whom
believe that knowledge will be a key driver of social and economic change in the coming century. To
understand better its complex and changing nature will be a great challenge ahead.