From Quality Control to Quality Monitoring and Organisational Learning

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Abstract

Quality control is an important and integrated part of the scientific system. However, developments in science are changing quality control into quality monitoring. New virtual and fluid organisational forms are emerging. Common boundaries are broken as for example in the "Triple Helix" and the "Mode 2" concepts. And the stakeholders in science are becoming interested in being involved. They want their evaluation criteria to be used, and they want evaluations to be done on a regular basis, because they do not trust the new scientific institutions to be left alone. Quality monitoring changes the assumptions for doing evaluations as part of quality control. Assessment of the societal value of research becomes increasingly important. Finally, quality monitoring emphasises organisational learning rather than controlling quality in scientific organisations.

Keywords: Quality monitoring, quality control, scientific quality, research evaluation, peer review, organisational forms, organisational learning.

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Introduction

The scientific control system is one of the core scientific institutions (Merton, 1973). Quality control done by peers is an integrated part of science as it ensures valid and reliable knowledge. Quality control is undertaken in several ways and has various foci, which means that we encompass traditional peer review of manuscripts for scientific journals, peer review of grant proposals, peer assessment of candidates for academic positions and research evaluations of a larger scale (Frederiksen et al., 2001; Hansen and Borum, 1999; Hemlin, 1996; Kostoff, 1997).

New developments in science and new perspectives on science are changing quality control. There are various reasons for these developments, and the most important is the growing recognition that science is indeed very closely connected to society – and should be. Concepts such as "Mode 2 knowledge production" (Gibbons et al., 1994) and "Triple Helix" (Etzkowitz and Leydesdorff, 1997) point in this direction. Moreover, it is claimed that the division between science and society is being renegotiated (Martin et al., 1996) and that it is even vanishing (Nowotny et al., 2001). Following this line of reasoning, science and science policy become more reflexive about the societal connection and the utility that science produces. This has important consequences for quality control. New organisational forms are emerging in the new system of knowledge production, new quality criteria are likewise appearing, and new stakeholders demand quality assessments on a continuous basis.

In essence we argue, and this will be elaborated below, that there are clear indications in the literature that much of today´s quality control is transforming into a monitoring system that has a process rather than product orientation, uses new criteria, has other foci and goals, uses different peers, uses different evaluation times and brings new perspectives to science studies. This development is important and interesting in itself, but it also changes our perception of why we do quality checks. Quality monitoring cannot be understood only as ensuring the trustworthiness of the knowledge production, but should mainly be seen as a means for organisational learning.

In this article we will trace some of the reasons for the shift of quality control to quality monitoring and discuss the consequences. In our conceptual analysis we draw mainly on the recent science policy and management literatures that discuss research organisation. Moreover, we rely on two Scandinavian cases to exemplify current shifts in the quality control system of science. The first case being science funding and new universities in Sweden, and the other a Danish research council. Accordingly, we will focus on systems and organisational issues related to quality control in science. In the first section of this article we examine some developments in the scientific system that drive it toward quality monitoring. In the next section we investigate what implications this shift has from a research evaluation perspective. Then we discuss two cases that illustrate some features of this development. In the next section we analyse what the change to quality monitoring and the two cases tell us about science by using a number of theoretical perspectives on science from the literature. In the concluding section we discuss how quality monitoring should be seen as a means for organisational learning.

New developments in science

The shift from quality control to quality monitoring is connected to new developments in science. Here we will focus on the two most important for our analysis of quality control: 1. New organisational forms, and 2. The reflexive turn in science policy.

New organisational forms

Scientific work is not – and never was - limited to university departments, but was also done in industrial labs, private and governmental institutes (Carlson, 1997; Pestre, 1997). It is even claimed that university scientists worked in industry as consultants in the early decades of the last century (Godin, 1998; Shinn, 1998). Despite this science studies quite often neglected scientific research done outside universities. However, the influential research policy literature by authors like Gibbons et al. (1994) and Etzkowitz and Leydesdorff (1997) have changed the foci of science studies over the last ten years. Increasingly we shift our attention to also include the research done outside traditional university departments. One reason being that research is now done in a "context of application" according to the aforementioned science policy analysts. These authors emphasize that we will find research carried out in "hybrid fora", which for instance could be research centres that connect researchers from universities, the corporate sector and public administration. In the literature about the Triple Helix it is argued that the connections between these different institutions also lead to institutions and the people involved beginning to perform tasks that previously were done in other institutions (Etzkowitz and Leydesdorff, 1997). The result is that new hybrid organisations emerge that do many different tasks and undertake several new responsibilities. This multitude of tasks and responsibilities is also explained by the fact that many of these organisations were established to make collaborations between researchers from different disciplines possible.

The new hybrid organisations are also different from traditional research institutions because they function on the boundary of different systems or spheres. Universities are mainly public organisations ruled by governments. Industrial laboratories are part of private firms that function in a market. Hybrid research centres are something in between. As such they are part of what in the science policy literature have been labelled "intermediaries", "boundary organisations" and "trans-institutional organisations" (Braun, 1993; Guston, 2000; Guston, 2001; Hemlin, 2001; Hemlin and Widenberg, 2001; Miller, 2001). A common feature is that these organisations are not governed or managed in the same way as traditional research organisations. Instead we find new forms such as "hybrid management" (Miller, 2001) or "network governance" (Braun, 1993;Hellström, 2001).

Another organisational development is the focus on networking in science. Science has always been based on communities of peers, and this has been expressed in many ways: Merton called it the "prestige hierarchy" (Merton, 1957) and others the "invisible colleges" (Crane, 1969). The rationale is the same – scientific work is performed and controlled by scientific researchers connected through a social network. The idea is old, but today it is accentuated by the envisioning of the future society as a "network society" (Castells, 2000). The coming society is viewed as being dynamic, constantly changing, open to innovation, flexible etc. Networks bestow these characteristics upon society in virtue of being open structures that can easily expand and integrate new nodes. Networks and network governance are generally seen as distinct coordination mechanisms in contrast to markets and hierarchies (Jones et al., 1997). As a consequence of this general social development, scientific networks no longer include only knowledge producers at universities. Instead scientific or rather knowledge networks include both knowledge producers and knowledge consumers interchangeably. Moreover, they involve different types of organisations – both public, private and hybrid – with different types of goals and changing structures (Jacob and Hellström, 2000; Callon, 1998; Delanty, 1998; Hellström and Jacob, 2001; Hemlin and Widenberg, 2001; Jacob, 1997; Leydesdorff, 2001; Ziman, 2000).

A third and related development is the evolution of virtual organisations in academia. Brick and mortar universities are in danger of being replaced by virtual universities (Dator, 1998). Both the commodification of and the increasing global demand for tertiary education are pointing in the direction of more virtual education (Greenhill, 1998). Virtual organisations are also created as a result of more interdisciplinary research connecting different research groups that are geographically separated. Often these virtual collaborations are made possible by new information and communication technologies. The virtual organisations can be organised in different ways. Hellström and Jacob (2001) mention three for example: 1. The cellular organisation with semi-autonomy from the larger organisation. 2. The patching organisation that constantly re-arranges itself. 3. The boundary-less organisation that sees organisation barriers as essential obstacles to success. The characteristics of the virtual organisations – autonomous, constantly re-arranging and boundary-less – can today be recognized in academic institutions and units. This raises the issues of research management and university governance (Hellström, 2001).

A fourth and last development that we want to stress is the growing number of contract researchers in academia (Jacob 1997; Jacob and Hellström, 2000; Ziman, 1994). In Mode 2 knowledge production short-term contract employment is beginning to be the rule rather than the exception. This changes the political economy of science because researchers now have to compete from project to project instead of competing for positions. The results of research project work, but more important the qualifications of researchers, are evaluated more often because of the increasing temporary research contracts. The latter means that in contrast to previous policies where tenure was a typical career step in academia, researchers are now constantly under pressure to perform competitive project research, otherwise they are out (cf. Ziman, 1994).

The reflexive turn in science policy

The knowledge producing (and consuming) system is changing as the above developments in organisations have shown. The change is to a certain degree intentionally designed by policy makers to develop the societal connection of science to let industry and society in general benefit more. Hereby the social connection becomes more explicit in the thinking of science policy makers. But not only does science policy strengthen the social connection - science policy thinking is also more reflexive about its own role. Reflexivity is one of the distinguishing features of late modernity according to authors such as Beck and Giddens (Beck,1992; Giddens, 1990; Giddens, 1991). In this context we argue that reflexivity stands for a science policy that analyses its own role and actions in society (cf. Woolgar, 1988). Moreover, reflexivity on an individual level also means that researchers begin to use the new science studies literature in understanding their own work. In this way reflexivity is a deliberate and intentional self-reflective thinking of one's work and activity as a researcher. This thinking can be contrasted with the tradition-based understanding of what you are doing as a researcher - an understanding that you do not reflect upon, but are socialised into.

The knowledge producing system and its institutions, e.g. research councils and universities, are also experiencing the reflexive turn in their operations (Delanty, 1998; Leydesdorff, 2001; Nowotny et al., 2001). Mode 1 knowledge production – similar to normal science in a Kuhnian sense - could take the scientific system and its institutions, processes and criteria as a steady starting point. This is not possible for Mode 2 knowledge production. In this mode it is necessary to continuously reconstruct the boundaries and connections between academia and society. The networks connecting science and society are not just there, but have to be promoted and facilitated all the time.

The reflexivity of science policy also means that new and different demands are imposed on universities by new regulatory bodies and the public (Delanty, 1998). More involved stakeholders both want and question the value of science. The "new social contract with science" (Guston and Kenniston, 1994; Martin et al., 1996) does not contain the same amount of trust in science and scientists (Gibbons, 1999; Ziman, 2000). In a reflexive society, trust – especially trust in knowledge producing institutions - has to be produced and reproduced continuously. The knowledge producing institutions, their organisation and their functionality cannot be taken for granted, but have to be monitored.

Both of these trends – the development of new organisational forms and the reflexive turn in science policy and research organisations – pull scientific quality control in a new direction.

Changes in the academic quality control system

Four common features of the new mode of knowledge production that are related to quality control are described in this section, because we claim that they will exert considerable influence and change on quality control (see Cohen at al., 2001;Gibbons et al., 1994; Etzkowitz, 1996; Leydesdorff and Etzkowitz, 1997).

First, a feature common to the Mode 2 and Triple Helix claims is the change in the organisational context of knowledge production, which means, as was mentioned in the previous section, that a diversity of different organisations of new forms arise and that new institutional formats are established. Gibbons et al. (1994) suggested that Mode 2 knowledge is produced in a process of volatility and uncertainty, demanding organisational development. Interestingly, this coincides with the fact that organisations in the private sphere, where knowledge is becoming the dominant interest (Nonaka and Takeuchi, 1995; Von Krogh, Ichijo, and Nonaka, 2000), are characterised by a number of changed features. According to authors in the management and organisational literature (e.g. Clegg, Hardy, and Nord, 1996; Goodman and Cyert, 1997; Daft, 1998) the following changes are taking place: a turn to complexity, individual focus, small-scale organisations, fluid models, penetrable borders, temporal durability, global connections, a knowledge and learning orientation, empowerment, less hierarchical and more decentralised firms, wise instead of strong leadership, management as negotiation (Grint, 1997), a development of a shared culture within the organisation, and an emphasis on communication. These organisational developments in private organisations are converging with the organisational changes in academic institutions.

Second, there are a number of common themes in the new research policy literature about transcending boundaries between basic and applied research, the crossing of borders in research between traditional university disciplines, and an enhanced interaction between universities, industries and governments (Bozeman and Rogers, 2001). Less strict boundaries between organisations will, we believe, influence goals and procedures in quality control, because they will be negotiated to suit the new demands.

A third common characteristic of the new system of knowledge production could be described as end-user orientation. Today research is: 1) carried out in a context of application where users will be involved, 2) demanded by public and private science users to be socially accountable, 3) bringing about a capitalisation of science. The user group point is raised by Gibbons et al. (1994) in relation to public controversies about knowledge. They argued that disputable knowledge or knowledge applications such as cloning of humans may give rise to an alternative knowledge or technology (cf. Xenox transplantations). The characteristics of the knowledge is that it is produced in collaboration with users in hybrid-fora and has an enhanced social accountability. A pertinent example is research in the wide bio-tech sector, where various interests mix. Furthermore, it is suggested by these authors that research evaluations are carried out during the process of knowledge production. It would then be possible to bring user groups into this process.

Fourth, it is possible to distinguish a number of features suggested in the new system of knowledge production that will more than the others directly influence the behaviour of scientists. We claim that it is the need for heterogeneous skills and knowledge, reflexivity, new careers, new organisations and new norms of science that will change behaviours. And through this change another kind of quality control will arise in the research system.

In summary, we claim that the four features in the development of knowledge production will change the goals, criteria and procedures of judgement of research quality, turning quality control into quality monitoring.

In the following sections we present two Scandinavian cases of science policy and universities. We have, as science studies researchers, but also as researchers in the Scandinavian research system, a reasonably good overview of the Scandinavian scientific system and its actors. In this system we chose two cases that showed a number of the characteristics of the transition from quality control to quality monitoring. By using these two examples we want to illustrate that there are indications supporting our theoretical analysis and claims. However, we do not wish to speculate about how dominant these changes in the quality control systems are. It is enough for our purpose in this article to show that there are typical changes leading to quality monitoring that occur in the academic system and society.

The Swedish case

This case study is divided into two short sections where we present recent Swedish research funding changes as well as changes in universities.

Research funding changes

Research in Sweden has since the 1960's involved non-university steered sectoral research beside what was viewed as academic basic and applied research. Sectoral financed research has, to a more limited extent than basic research, been subject to academic quality control and therefore criticized by the academic community. The arguments have been: since sectoral research has not been peer reviewed (in the traditional sense) it must be of a lower quality than research that has. During the 1990's we have seen a new research actor in Sweden, namely the so-called strategic research funds. The purpose of these funds is to support goal-directed research, which is viewed as neither basic, applied nor sectoral (Gustafsson, 1997; Kasemo, 1997). One example of research funding was the eleven cross-disciplinary consorts in material sciences (Widenberg, 1998). Originally financed by the Swedish council for private enterprise and technology and the Natural science research councils, the Foundation for strategic research funded projects for 5-10 years. Research projects should aim at cross-disciplinary research mainly in physics and chemistry, industrial relevance, international research collaboration, and a strong research leadership. When the four objectives are met, according to the evaluations, project financing is terminated. Also, negative developments may of course terminate funding, and this has occurred. A similar development is seen in military agency research funding programmes in the USA. Funders invite research participation by bringing groups of investigators together and play a fairly direct role in formulating a research programme (Etzkowitz, personal communication).

The first conclusion to be drawn from the Swedish strategic funds is that the research policy is directed towards supporting Triple Helix-Mode 2 activities, e.g. transdisciplinary research, research with industrial and societal relevance and enhanced international collaboration. The second is that quality control starts early in the process of knowledge production, because traditional peer review is replaced by modified peer review (see Hansen and Borum, 1999). The latter has a new task and focus (e.g. assessing a research programme and not an individual research effort), uses different procedures (e.g. depends on second order material, engages in site visits) and has a different outcome (less focused on the quality of publications, but more on the appropriateness of problems, the organisation of research etc). Thirdly, a consequence for quality control of the new strategic funds is that there is less traditional peer reviewing and more user judgements (e.g. active interest by industry).

Changes in universities

Transdisciplinary oriented and single faculty shaped new universities have emerged on the Swedish scene and elsewhere (see Etzkowitz, Webster, Gebhardt, and Terra, 1998). The Swedish dominant research and higher education policy has since the 1980s been linking universities and society closer, particularly by focusing on regional development. This will influence quality control. Three rather new university colleges (Mitthögskolan, est.1993/95, Södertörns högskola, est.1996 and Malmö högskola, est.1998) are relevant in this context[1]. Mitthögskolan, which like the other two, is striving for university status, presents itself on the world wide web as a multi-campus network university of four mid-Sweden cities (Härnösand, Sundsvall, Örnsköldsvik, and Östersund) focusing on "the forest as a resource, entrepreneurship and leadership, electronics and telematics, the development of networks, and tourism". (www.mh.se, 2001-10-30).

The new university college in the Stockholm area at Södertörn, describes itself as "multi-cultural and multi-disciplinary". Researchers in the social sciences and the humanities study societal, historical and cultural aspects of the East Sea region (Östersjöregionen), which connects Sweden, Denmark and Finland with other East and Central European countries. In the sciences they focus on research in the expanding disciplines of chemistry, biology and molecular biology. Södertörn

[1] Sweden had 49 institutions for higher education in the year 2001: 15 universities (13 in the government sector and 2 in the private sector), 24 university colleges, 7 Arts colleges and 3 colleges for health sciences (National agency for higher education, 2001). The majority of the university colleges are smaller institutions with no or limited Ph.D. training and scientific research.

university college emphasizes the connections between research, higher education and society on its web site (www.sh.se, 2001-10-30).

The third and most recently founded university college in Malmö is part of a virtual network of universities in southern Scandinavia (Sweden and Denmark). Altogether the new virtual Oresund University comprises 12 universities and colleges in a region, where 3.2 million people live. Knowledge-intensive companies are already establishing themselves here, according to the information on the Internet. The profile areas of Malmö university college are multidisciplinary: gender, international migration and ethnic relations, and, the economy of nature and resources. There is also a faculty of odontology. Viewers of the web site are also informed that there will be a new office for "the third mission" (knowledge transfer and dissemination), which will enhance collaboration with private companies and public organisations in the region (www.mah.se, 2001-10-30).

In conclusion, these new universities are embedded in society in a way that distinguishes them from traditional universities. First, they have typically multi- and transdisciplinary departments, to which teaching staff with multidisciplinary background is recruited. Second, they are closely connected to their regions by co-operation with regional business companies and public authorities. Third, they show new organisational features such as dispersion and networking between educational sites and with other universities.

The Danish case

In Denmark we have chosen a rather new research council for, what is claimed as basic research, the Danish National Research Foundation (DNRF) as an illustration of the new developments in knowledge production and quality control[2]. Together with the six general research councils for all the sciences, DNRF comprises the public Danish research funding system. Interestingly, DNRF was established to support basic research as an independent supplement to the other parts of the Danish research granting organisations. By means of its support for centres of excellence, it has taken a unique position within Danish research policy, because no other public granting organisation supports basic research on such a scale and time period as DNRF. It started 1991 as a support agency for outstanding basic research in any research field. It supports large and long-term research efforts through centres of excellence, that are geographically or less often virtual research environments consisting of senior researchers, post-docs and a number of Ph.D. students. In addition DNRF supports Ph.D. education and training. The normal granting period is 10 years for a centre of excellence. In 2001 DNRF supported 25 centres which had a total budget of 250 million Danish crowns a year, which means that an approximate mean budget a year for a centre is 10 million Danish crowns (about 0, 8 million USD).

On the DNRF website (www.dg.dk, 2001-07-02) it is stated that 9 new applications were selected for granting in January 2001. Among the centres of excellence supported we have selected three examples: the Danish Lithosphere Centre, the Centre for Metal Catalytic Reactions, and the Centre for Molecular Plant Physiology. Also, two doctoral schools were supported since 1997: BRICS International Ph.D. school in datalogy at Aarhus university and The International Medico-technical Ph.D. school at the Centre for Sensory-Motor Interaction at Aalborg university.

[2] The national Danish research and higher education system contains 11 universities. In contrast to the Swedish sectoral research funding organisations, which allocate research money mainly to university researchers, Denmark performed sectoral research at 29 independent research institutes (Sektorforskningens Direktørkollegium, 2000).

Quality control at DNRF involves ex ante evaluations of grant proposals, but also ex post evaluations of centre activities after the 10 years final granting period. However, the foundation also uses a monitoring system, which means that evaluations are carried out after 3-4 years of a centre's establishment. In addition, there is continuous contact between the DNRF research directors and officers and the centre leaders and its researchers. International peers participate in ex ante and ex post research evaluations as well as in the monitoring of centres.

The aims of the DNRF quality control are to certify research of a high, international quality. But not only this, centres are also and surprisingly asked for a contribution to society in its widest meaning. A third aim is that Ph.D. training is done within the centres. In addition to these aims DNRF has the ambition that centre research should continue after the granting period. This additional aim is linked to the training of new researchers in the doctoral schools financed by DNRF.

The new and interesting feature in the quality control of DNRF is that societal values play an important part in the evaluation. In the first place, the societal relevance appears as a more or less contradictory aim to internal scientific value (research done for its own purpose by developing theories and contribute to scientific development). However, if viewed from the perspective of the new models of scientific or knowledge production (e.g. Mode 2 and Triple Helix) this is less problematic, since these ideas lead to a view on scientific development where distinctions between basic and applied research become blurred. Moreover, another feature of DNRF converges with the message of the new science policy literature. DNRF is also interested in the management of the centres that is how leadership is performed, how the research work is organised and how researchers and Ph.D.s work together at the centres.

In conclusion, five features of the Danish Basic Research Fund make it an actor in the new system of knowledge production. First, it incorporates societal values in its centre research evaluations. Second, there is a rather close monitoring of centres and half-time evaluations. Third, the foundation focuses on the centre's activities rather than on individual researchers. Fourth, evaluations are not only controlling, but also equally directed at learning for the centres and the foundation. Fifth, there is an interest in research management as an important part of research. We believe that these features are becoming more prevalent in quality control making it a monitoring process.

A summary of the transition from quality control to quality monitoring

Against the theoretical analysis and the two cases presented we attempt to summarize and depict the main differences between quality control and what we call quality monitoring in table 1. First, we argue that there is a change in criteria when doing quality monitoring compared to quality control. Not only will scientific criteria such as originality and methodological rigor be used, but also traceable influences of industrial developments and regional or governmental policies will play a more important role. This could be seen in both of the cases[3]. Second, we have in new large-scale evaluations of science seen a transition from the assessment of individuals to organisations that are aggregates of scientific production and organisational issues including network and collaborations focused in quality monitoring. This change was pointed out as a result of the analyses by Hansen and Borum (1999) as "modified peer review", and could also be traced with the research funds in the two cases. Third, we have already discussed the goal of traditional peer review to secure valid and reliable knowledge. This will naturally and always be part of quality control, but to a greater extent monitoring will incorporate socially tested knowledge claims, for example by bringing in ethical and political issues. This was found in the Swedish case with an orientation of new universities towards education and research on multi- and transdisciplinary issues on the societal agenda. Fourth, the transition will bring new peers to judge the knowledge process and results because traditional peers do not possess the competence to evaluate all social issues of knowledge claims. This makes it necessary to involve users, management consultants, and even lay persons as peers (cf. Rip, 2001). Both cases supported this point. For example the Danish study is an example of a research council that involves consultants to assess the R&D management in centres of excellence. Fifth, there is a shift in time for judging the quality of knowledge from knowledge being viewed as a scientific article or end product to an on-going process where judgements are made in the process of knowledge production, that is a monitoring function in both cases. Finally, we would like to stress that transitions in quality control systems will influence how science studies will be done. Science studies will shift their perspective from philosophical and sociological theories to include management theories, in which science will be viewed much more as work processes and an organisational activity where learning is focused. This point is hardly supported by the case studies, but rather a consequence of quality monitoring on an organisational level. We will therefore return to this point in the following sections.

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[3] That this change in criteria is not restricted to Sweden and Denmark but also incorporate the USA is supported by the fact that NSF now has formulated an impact on society criteria as one of its major criteria for research funding (Etzkowitz, personal communication)

Table 1. The Transition from Quality Control to Quality Monitoring in Science

Dimension	**Quality Control (product orientation)**	**Quality Monitoring (process orientation)**
Criteria	Scientific	Scientific and societal
Focus	Individual researchers	Organisations, networks
Goal	Valid, reliable knowledge	Socially robust knowledge, Learning
Evaluator	Traditional peers	New peers, users, consultants lay persons
Evaluation time	After production	Continuously
Science study perspective	1st order: Philosophy and sociology of knowledge	2nd order: Knowledge management, organisational learning

New perspectives on science

Features of the chosen cases support the claim of the transition from quality control to quality monitoring. New quality criteria are used (e.g. societal relevance was introduced to assess basic research in the Danish case) and the assessments are done on a more regular basis. It is not only individual researchers, but also networks and organisations that are being evaluated, and the evaluators are not only scientific peers, but also users, lay people and consultants. But several central questions remain: Is this development good or bad? Is it representative of science? Quality control has always been crucial to the scientific system, so what will happen when it is gone or changed fundamentally? Can science prevail without it?

To answer these questions it is necessary to look at some of the new perspectives on science. These perspectives are in our view so different that we also need to change our conception of science in general. The new conception of science is the proper background when we try to answer the question whether the transformation of quality control to quality monitoring is something we should support. The reason for this is that the move to quality monitoring is often problematic when seen from a traditional perspective on science, but not when your perspective is a new understanding of science. Here we look at four new perspectives on science: 1. The problematic distinction between basic science and applied science. 2. From certified knowledge to socially robust knowledge. 3. From the individual researcher to the organisation. 4. The disappearance of the division between society and science.

The problematic distinction between basic science and applied science

The Danish case shows that centres of excellence established to make basic science also can be expected to contribute to society and that quality criteria regarding social relevance can be used to assess these centres. Following the common perspective on science this would be an example of blurring of boundaries and categories. The argument would be that basic science cannot be applied – and attempts are doomed to fail and will only eventually end up ruining the potential that basic science contains. The common definition of basic science is precisely that it is not applied (see the Frascati Manual, OECD, 1994). But new studies suggest that the perceived distinction between basic and applied is problematic, although it has been raised previously in the literature (see e.g. Pelz and Andrews, 1966).

In twenty-eight case studies of Knowledge Value Alliances (KVA) in the U.S.A. Bozeman and Rogers (2001) showed that researchers in basic sciences doing fundamental research were part of collectives and systems of innovation and development including manufacturers, lab technicians etc. in commercially relevant activities. We interpret these findings as an indication of research that is depicted as fundamental or basic is "used" in a "context of application", that blurs distinctions between what is perceived as basic and applied research.

In an interview study of fifty scientists and research policy makers in the UK and USA by Calvert (2000) found that ´basic research´ was something that both groups protected as a valuable symbol, but that scientists perceived that they must make their research appear applied to get funded, while policy makers stressed that ´basic research´ is secured and that there is no turn to more applied research funding. Calvert concluded that both groups used ´basic research´ in a rhetorical way and when it worked for them.

Ziman (2000) claimed that the pure or basic research concept is strongly ambiguous and dependent on the context in which it is used. It could be called basic research because a scientist feels free to do what s/he thinks is the most interesting at the moment in her/his field. The funding organisation of the same research perhaps views this endeavour as applied because s/he got research money from a budget designed to promote advances in material sciences. Moreover, the university where the scientist works could make a third interpretation. Their board might view the research being done as basic research because it is carried out in a physics department where it is generally perceived that scientists solve basic physical problems without any application in mind. Hence, in this way basic and applied or even strategic research labels become blurred.

Stokes (1997) argued for the hypothesis that the original architect behind the two concepts (basic and applied) and the distinction between them, Vannevar Bush, did not believe in the distinction himself. He was an engineer from MIT who was aware of how science can be basic and applied at the same time. Instead, Stokes believed that Bush for tactical reasons used the two concepts. The tactic was used in 1945 to convince the US government to fund science and at the same time to prevent the government from controlling it. Government should fund basic science because it yields general knowledge that afterwards can be applied through applied science. But basic science cannot be controlled as far as applied science can, and therefore should not be under governmental control, but be self-governed. His tactical "trick" worked, and the past fifty years we have believed in the trick making us think that science cannot be basic and applied simultaneously. It is this perspective on science that is gradually eroding today.

As a result of this implosion of the perceived distinction between basic and applied science, knowledge can be fundamental, basic, and very general and at the same time very useful. And the utilisation of this knowledge is indeed a relevant measure of its social value.

From certified knowledge to socially robust knowledge

If the traditional understanding of science and scientific knowledge has at least one defining characteristic - then it is that knowledge is defined as "justified true belief". It is part of what could be called "the legend of science" (Ziman, 2000). An idea of what truth is, together with the idea of objectivity is the fundamental basis of the view on science originating from the philosophy of science tradition (e.g. Popper, 1959/1995). The "correspondence theory of truth" is the most well known idea of truth. This idea also influences the way justification is perceived. The scientific method shall ensure that your belief is a true representation of the field under study. Consequently, knowledge is true representations of reality produced by scientific methods. From this perspective quality assessments should test whether the proper scientific methods have been used, and if so the result is certified knowledge.

One problem with this definition of knowledge is that the philosophers of science have never been able to produce a convincing account of what the right method is that secures certainty. One of the fundamental difficulties is how you measure representations against reality itself, because it is exactly our best and most advanced scientific beliefs that control how we perceive reality. We don't have "a bird's eye view" on reality or "a view from nowhere" that can tell us how reality is unconnected to or untouched by our scientific efforts to decide how it is.
As a consequence of these problems another view of knowledge has been proposed. Pragmatist philosophers (e.g. James, Dewey and Rorty) consider knowledge as something that makes action possible. The idea that is expressed could be phrased in

a popular way like this: When you know what you can do you, you know what you know. Pragmatist philosophers opposed the idea that it could be possible to make representations of reality. Instead they proposed an understanding where knowledge is established through its use. Knowledge is a way of world making.

The pragmatist view of knowledge makes sense to us, and its conception of knowledge has severe consequences for our understanding of quality assessment. Quality control in the sense of assessing the truth of some knowledge claim by judging the correspondence between the claim and reality itself is impossible. Instead knowledge should be tested by its ability to make the knower powerful and by how trustworthy the knowledge is. Nowotny et al. (2001) argue that knowledge is not only developed in a "context of application" (Gibbons et al., 1994). Researchers anticipate and reflexively engage with the consequences and impacts that the research activities generate. The knowledge generated by this "implication process" Nowotny et al. call "socially robust" (see also Nowotny 1999). Socially robust knowledge is produced through a process where new scientific results are tested "in vivo" in the relevant social context. This contextualisation usually happens in "trading zones" (Gallison, 1997). These are zones occupied by inter-disciplinary knowledge producers coming from different scientific disciplines and different societal sectors. Thus, research is influenced and improved by the social knowledge and capital that is generated by the social discussions, uses and tests of the scientific results. Hereby, it becomes more trustworthy and "socially robust".

This view of knowledge indicates that the social value of knowledge, not only is a relevant measure of the application of knowledge but also a measure of its scientific value in itself. As a matter of fact a radical pragmatist would claim that it is *the* only measure of the scientific value. Anyhow, evaluating the social relevance in quality control is not a marginal and secondary activity anymore. It is just as important as peer review using the traditional scientific criteria (e.g. coherence, proper use of methods).

From the individual researcher to the organisation

The above pragmatist view of knowledge has also important consequences for the goal of science. Science can no longer strive to produce knowledge for mainly its own sake. The problem is twofold. The first problem is that science cannot assess with absolute certainty what truth is, although we may strive for it. The second problem is that knowledge is not produced in a vacuum. You can have ideas and make knowledge claims in isolation, but before this knowledge is validated through use, through social interaction or by people wanting to use it in practice, it is not yet knowledge. You have to use it before you know what you know. Therefore knowledge application is not a residual activity initiated after knowledge is produced. It is produced and used in the same instant. As a consequence of this the goal of science is not only the production of true knowledge, but also to organise itself as an institution in such a way that its stakeholders consider it as trustworthy as possible and therefore can accept and use the knowledge. This is the new goal of science.

In this way science is no longer viewed as the republic of lonely seekers of truth (Polanyi, 1946). Instead science is perceived as a social institution based on co-operation and teamwork. In addition to viewing knowledge as created in social interaction, new transdisciplinary problems and the need for huge experiments and apparatus necessitate this development. This development also indicates that the proper "target of assessment" is not the individual researcher, but the research environment, the network or the organisation connecting people in the trading zones. The focus on institutions, environments, organisations and social networks also change scientific quality control. Now it becomes important to assess the management of boundary permeability, connections and networks. Scientific organisations cannot hope for more truthful descriptions or representations of reality; they can only aim for becoming more trustworthy in their environment in the future. However, it is only possible to judge this by assessing their management performance until now. As a consequence there is a new focus on management and organisational issues in quality control.

The disappearance of the division between science and society

The three changed perceptions of science above are not the only ones – others could be chosen. However, they all point in the same direction, namely that science is no longer seen as a special kind of divine cognitive activity. Instead science is "just" another social knowledge-producing institution, one amongst many in modern society. But it is the institution that – because of its historical origin – should be the most advanced in looking critically and reflexively on its own institutional knowledge base and therefore at least until recently the most trustworthy.

Following this, science is not anymore viewed as an autonomous and free-floating entity disconnected from the rest of society. One of the most prestigious and strongest ideologies regarding science must be abandoned. Academic freedom is utopia. Science is a part of society (cf. Pestre, 1997). In fact, science is "only" a special reflexive way of organising and managing social institutions that work with knowledge. Therefore science is not disconnected from society, but is immensely dependent on the social dimension. The importance of science in society is actually growing as it is envisioned in the term "the knowledge society" (Stehr, 1994).

This view of science has two important consequences for quality control. First, evaluating science is not different from evaluating other social institutions. When our case organisations experience that their assessments of different scientific entities are like all other evaluations done in society, it is not a problem but a new condition. There is no fundamental difference between scientific quality control and the determination of best practise in industry done by consultants; they use more or less the same concepts and methods. There is however a difference in the degree of reflexivity. Secondly, as science is now viewed as a special kind of reflexive organisation of knowledge work the continuous examination of how science organises itself becomes central to scientific work. In fact, you could argue that this is the core of science. If the organisation of the tests, laboratories, seminars, etc. is not up to date or if it is done in a traditional, ideological and un-reflexive way it is not scientific. Science can only, and this is a fundamental point we make, be established through continuous evaluations of the work, activities and products that are claimed to be scientific. Hence, continuous monitoring instead of infrequent control will become essential to science.

Against this background – the new understanding of science – quality monitoring is not another bureaucratic procedure or a development we should try to stop. On the contrary, quality monitoring is a way of establishing scientific knowledge. The social relevance should be determined, the organisation and the management should be evaluated, and it should all happen on a continuous basis. Without quality monitoring science may possibly even be marginalised and loose its authority to other new knowledge producing institutions.

Conclusion: The organisational learning perspective

In the past quality control was integrated in a scientific system that should ensure true and reliable knowledge. We saw science as based upon divine cognition done by individual researchers and it was their work and results that should be evaluated. Ultimately quality control should test and control how the knowledge claim corresponded with reality.

Now we view science as a social institution that should produce socially robust knowledge and shift our focus to the scientific environments and their ability to reflect upon their own background for producing knowledge and their own position in the overall system. This shift in perspective is brought about by the developments traced in this article – both through theoretical analysis and through the case studies. As a consequence of this shift in perspective, science quality issues do not so much concern the relation between knowledge and reality, although we do not claim it should be completely abandoned, but instead relate to the knowledge environments' competencies and their ability to learn. This shift in the view of quality in science also means that quality monitoring comes very close to knowledge management and organisational learning.

Different scientific organisations (e.g. the universities) have already been connected to knowledge management (see e.g. Rowley, 2000) and to organisational learning (see e.g. Patterson, 1999). This is not surprising, when you consider that they all are archetypical examples of knowledge-based and knowledge-intensive organisations. But we claim more than that, namely that organisational learning and knowledge management is more than a new fashionable management discourse for scientific organisations. We see the move from quality control to quality monitoring as signalling that knowledge management and organisational learning actually is the one most scientific task to perform when you do scientific work, because science and scientific values actually depend on a knowledge environment's ability to reflect upon its cognitive, social and institutional basis.

The organisational learning perspective on science and research has been proposed before (e.g., Hansen 1994; Gulddahl 2000), but has not been developed in a thorough way. Now we have to take this perspective seriously, because traditional quality control is changing and being supplemented by quality monitoring. And you cannot understand and perform quality monitoring if you do not do it from a learning perspective. Hence, our conclusion is that the shift from quality control to quality monitoring conveys the message that we should commence studying how scientific organisations and environments learn. From this perspective organisations are not becoming scientific solely by producing knowledge representing reality, but by reflecting on their own ability to learn. The will to learn and reflect is the trademark of the modern scientific organisation.

But what is organisational learning? We believe in line with Dodgson (1993) that organisational learning should focus on learning processes rather than on learning outcomes. The latter are of course important indicators that learning has taken place, but it is how the organisation learns as a process that is of immediate interest. This means that the way organisations build, supplement and organise knowledge and routines are important in organisational learning (see also Harvey and Denton, 1999), and it is this view that makes organisational learning come close to knowledge management. Learning happens when individuals in organisations have seen the results of their actions towards the organisational goals. By reflecting upon and storing the knowledge of actions that lead to these results, individuals become aware of and learn what to do in similar and future situations (knowledge schemas). This knowledge is individual but is shared with others in various ways (explicitly and tacitly) if organisational learning is going to take place. In the same vein, scientists can be seen as storing their problem solving by disseminating knowledge in publications, keeping information in databases for others to use and by communicating in a number of ways various aspects of their research with other scientists and users. If this knowledge is shared between members of an organisation and made available, we may say that the organisation is learning.

But it is not enough for organisational members to learn from each other. The learning organisation also has to learn about the external environment outside the organisation. Virtual organisations are the most extreme cases, because they have more or less dissolved the boundaries to other organisations and networks. In this way they are part of an open learning system reminding us of the innovation systems notion (see Edqvist, 1997). A very important task to perform to produce organisational learning is a perception and understanding of the organisation's position in the larger environment (cf. Pfeffer, 1997). Because of this, the multitude of quality criteria used in quality monitoring is not a problem but a strength, because it helps the scientific organisation to produce information on its milieu. This externally oriented learning takes place in constant communication with a number of various actors (other researchers, grant givers, knowledge brokers, industrialists, politicians, end-users etc) in knowledge production. Moreover, it takes place during all phases of production from choosing and formulating problems all the way to solving them. Keeping track of these learning processes for the organisation will make the organisation, or in some instances even the networks that the organisation and its researchers are involved in, stronger because they learn how to take action in future situations. Organisations that use quality monitoring must of course be adaptive and change before real learning can happen. This means that the organisation is flexible in such a way that structures change and management is a pervasive phenomenon.

Quality monitored organisations react and adapt to internal changes and external influences through learning.

We have here just touched upon what organisational learning could be in a scientific context, because the change from quality control to quality monitoring means that we have to understand the learning in scientific organisations better. But it is not enough just to apply the general knowledge of organisational learning and knowledge management to the scientific sphere. We need more and new conceptual analyses and studies to be done.

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