How online communication may affect academic knowledge production
Some preliminary hypotheses

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1 Introduction

Recent developments in communication technologies are about to change working and collaborative patterns of academics. Online and offline Internet conferences as well as discussion forums of all kinds, exchange of drafts of joint papers and resource sharing around the globe seem to convert academia into a global research village. Since communication lies at the very heart of the academic enterprise we need to ask whether these new tools and modes of communication will impact on what academics actually produce. We may hypothesise that just as the size and type of the chisels used by the sculptor impact on the shape of the statue, the outcome of academic knowledge production will be different whichever mode of communication is used during elaboration.

This paper is part of a wider research project carried out at the Institute of Technology Assessment in Vienna where we explore the impact of information and communication technologies (ICT) on academia.[1] We coined the term "cyberscience" (Nentwich 1999) to depict the gradual move from traditional science (including also the social sciences and the humanities) where computers and telecommunication played only a marginal role towards a new type where, in particular, the Internet seems to have changed the way academics produce knowledge. This research project proceeds in four steps. *First*, we looked at the technological development which may have an impact on academia. In particular, we monitored how the Internet evolved, how new software is being developed to help (not only, but also) academics around the globe to communicate with each other on a bilateral as well as a collective basis, to retrieve and store information, to publish in quite distinct ways in electronic formats and so on. In a *second* step, we scanned the literature of a number of fields such as library, information, computer, communication sciences as well as the sociology of sciences and of technology with a view to get a broader picture of what actually happens in the various disciplines and how researchers and actors in the field (e.g. librarians and publishers) assess the development. In particular, we looked at how these new technologies impact on the roles played by the various actors in academia (e.g. what new roles librarians play now as "cybrarians"); on the way academic knowledge is produced collaboratively and at distance (e.g. in virtual institutes or via electronic conferencing); on how it is represented in new formats (e.g. hypertext or hypermedia); on the publication system (e.g. whether the printed academic book or commercial publishers will survive); on how quality is assessed and controlled (e.g. via new forms of open refereeing); on the teaching system (e.g. through tele-teaching and virtual universities); on the legal framework (e.g. old copyright provisions may not be adequate any more in the digital world); and finally on the various disciplines (e.g. there are major differences in the use of ICT between them which need to be explained). Our main focus being to find out what qualitative impact the advent of the new technology actually has on how academics work and what they produce, we are now in the (*third*) phase of elaborating a number of hypotheses to be tested in a series of interviews later this year. In the *fourth* and concluding phase of the "Cyberscience" project we will incorporate the empirical results into our main analysis with a view to model the impact of ICT on academic knowledge production.

In this paper, we will not report the findings of the first and second phase of the project, but put forward some preliminary considerations reflecting upon in the early third phase, namely *how ICT may affect the substance of research*.

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[1] For more details and related publications, see the project homepage at <http://www.oeaw.ac.at/ita/cyberscience.htm>.

2 Cyberscience and the substance of research

> "A growing number of colleagues testify that a few weeks of being active on the networks changes one's working life." (Okerson 1991, 18)

There can be no doubt that at the beginning of the 21st century academics in almost all disciplines work quite differently than only some twenty years ago. In most scientists' offices, the computer has replaced the typewriter, the phone rings less often than the E-mail programme reports new messages in the inbox folder and many of us got acquainted with the pleasures and woes of retrieving information through the Internet. This list of obvious changes could be extended easily, but the question we want to approach here is whether these have the potential to influence the content of the research. In other words, does the application of information and communication technologies in academia affect *what* actually comes out of the activity of researchers as opposed to *how* it is done?

There is not much in the literature trying to address this question yet, rather some authors seem aware of the issue, but focus on different aspects. For instance, Walsh and Roselle (1999, 57) argue that the impact of the new forms of scientific work organisation (multi-site work teams, telecommuting, distributed organisations, virtual organisations and other forms of geographically dispersed but networked teams, such as collaboratories and extended research groups) is not yet clear but they imply that what they and others call "balkanisation of science"[2] may indeed have an impact. Or else Kling and Covi argue that "(i)n principle, paper and electronic media need not influence the scholarly quality of a book or journal. But paper and electronic media do have significantly different material properties, and that influences some of their social properties." (1995) When elaborating this point, however, these authors do not as much focus on the social properties, but more on the evolving working patterns.

What follows is the first attempt to systematically map the possible consequences of ICT on the substance or content of research. At a first level, we may distinguish between indirect impacts resulting from changing work modes and more direct, content-related consequences.

Among the "*indirect*" group we may count the impact of the likelihood of more co-operation and multi-authorship (2.1) as well as of enhanced productivity and efficiency (2.2), not least because of changes in the timing of research projects (2.3). Here we may also hypothesise that an overall improvement of quality may result from a better fit of expertise in extended research groups (2.4).

In the "*direct*" group we will find, first, aspects related to methodology (2.5), including the thesis that inter- or transdisciplinarity and ICT are interrelated (2.6) and the idea that the Internet favours creative chaos, interactivity and more participatory modes of knowledge production (2.7). This also includes the possibility that due to the new information channels, different kinds of information may form the starting point of a research enterprise (2.8) and the choice of subject may be affected (2.9). A final set of observations relates even more directly to the content, i.e. the results. Do we have to expect different types of results (2.10)? Does a different kind of knowledge representation impact on the knowledge itself and on the thinking and reasoning behind it (2.11)? Furthermore, we may postulate that, on the one hand, the representation of the results will become less stable and more dynamic in an electronic environment (2.12), but on the other, possibly more transparent (2.13) and more standardised

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[2] With this rather strange term they mean the observation that the Internet allows for ever smaller sub-communities of researchers to have a sustained working relationship regardless of physical distances, leading to an ever more fragmented landscape of academia, not unlike the patchwork-like, ethnically split Balkan region.

(2.14), the latter also including a possible improvement of the connectivity of the research (2.15). In the main part of this paper, we shall discuss these hypotheses in turn.

2.1 More collaboration, multi-authorship?

The Internet can be said to be mainly two things: a huge repository of resources (texts, databases, images and the like) and a very convenient and fast means of communication. It is the latter aspect which makes it so attractive for academics seeking to collaborate with fellow researchers at other places around the globe. This is not the place to describe in detail which technologies facilitate distant co-operation, a few catchwords should suffice: asynchronous exchange of E-mails, synchronous E-conferencing with application sharing, collaborative writing tools, resource sharing (databases, remote experimental tools) etc. A number of studies show that collaboration is increasing over the last decades. For instance, scientometric data show the increase in multi-authored papers, in particular in the natural sciences (e.g. Thagard 1997). Walsh and Maloney (2001, 3) show that “while the number of international collaboration papers approximately doubled, there was a nine-fold increase in the number of publications by large international collaborations.” Scientific work is thus increasingly geographically distributed. Walsh and Maloney explain this by “a combination of the increasing scale of scientific problems, changes in funding patterns, and perhaps an overall increase in the number of scientists, as well as the availability of Internet-related technologies” (ibid.). Thus, multi-authorship is not only due to computer-mediated communication (CMC), but CMC certainly favours multi-authorship.

Collaboration is not only increasing, but collaborative patterns themselves change. As Orlikowski and Yates (1994) argue, CMC seems to “both transform and reinforce the existing structure of communication within a community” (quoted by Walsh et al. 1999, 64). Walsh and Roselle claim that the prior empirical work on the effects of the Internet on science would suggest that scientific work is changing in profound ways. They argue that “the most significant change may be the transformation of collaboration patterns.... These changes have not been caused solely by the presence of this new technology. Rather, the new technology has facilitated this change in work patterns.” (1999, 71) Finholt who has studied a number of virtual laboratories which he called “collaboratories” assumes that the transformations from laboratories to collaboratories, from physical to virtual co-operations, to a global workplace instead of national or local ones do not necessarily represent progress. He argues that “collaboratories may not make scientific collaborations better or easier. However, it is reasonable to assume that collaboratories will make scientific collaborations qualitatively different and that use of collaboratories will introduce a new set of trade-offs and constraints in scientific work.” (1997, 33) Harnad (1990, 4) goes one step further arguing that scholarly skywriting – the participation in electronic discussion and newsgroups as well as in open peer commenting in innovative E-journals – will be so collaborative, to the point that it will even be “depersonalised, with ideas propagating and permuting on the net in directions over which their originators would be unable (and indeed perhaps unwilling) to claim proprietorship”.

One may argue that the pure fact of more people being involved in a project changes the type of outcome: more people contribute and have to agree to the final text or other outcome. This typically involves a number of editing rounds where the text circles among the collaborators. Each member of the group is likely to both try to get his or her message across and into the final paper and to be convinced or to compromise over the course of the project. Hence, co-operative papers may be expected to be less “edgy” and more consensual. Seen from this angle, some of the scholarly discussion which normally takes place after the single-authored paper is being published is already part of the production process itself. In addition, we may also hypothesise that papers become “richer”: if academics from more than one cultural background are involved then perhaps a greater variety of ideas is incorporated into the research. This is not to say that co-operative projects will always lead to the effects just described. It may as well be, in general or under particular circumstances, that co-operation may lead to sub-optimal results, exactly because of the need to compromise which may hinder the formulation of exciting new ideas.[3] In both cases, it is likely that increased collaboration may affect the outcome. Rossman concludes that "(t)he primary importance of computer tools for the electronic university lies not in machines that will think for scholars but in scholars using such tools to amplify 'collective intelligence', bringing many minds together for more effective collaborative research" (1992, 58, quoted by Gresham 1994, 49).

Furthermore, if the authors are dispersed and hence CMC is part of the process, the selection of the *type* of CMC will affect the outcomes (Walsh et al. 1999, 58, quoting Orlikowski and Yates 1994). Whether written, asynchronous communication (E-mail) or synchronous video-conferencing is the main type used in a collaborative endeavour, may affect the type of collaborative effects according to the significant properties of the medium.

2.2 Productivity/efficiency enhanced?

A second possible impact of ICT use on the substance of research is again an indirect one. If the productivity of the academic endeavour increases, then, one may argue, we would not only have to expect more and faster results but as well new types of results. This may be because the knowledge produced in a field is almost always interdependent and the more related elements there are, the more productive interrelationships are likely, in particular if a "critical mass" is reached. In any case, if we can show that CMC improves productivity or efficiency of the science system as a whole and/or the individual scientist then this would have some significance for the quality of the research.

Massy and Zensky define "productivity as the ratio of outputs to inputs, or more generally as the ratio of benefits to costs" (1995, 5 s.). In these author's view, productivity can be improved by either doing more with more ("producing significantly greater benefits, encompassing quality as well as quantity, at modestly greater unit cost"), by doing less with less ("spending significantly less money while limiting benefits reductions to modest levels"), by doing more with less ("producing greater benefits while spending less money") or by doing more with less ("productivity also can be increased by improving quality at the same unit cost"). Note that in these definitions, "quality improvement", hence something related to substance, is closely related to productivity and vice versa. It is certainly „too early for a definite answer" (OECD 1998, 224), but we shall look at the available evidence from both a systemic (below 2) and an individual view point (below 1). Note that we shall treat time-related aspects in the following sub-chapter.

(1) Productivity of the scientists

In many respects the work of academics has been facilitated by CMC. First, not only is the information available increasing, it is also much easier to access it (literally from the researcher's desk). The OECD report comes to the conclusion that "ICT has increased researchers' ability to access information by supplying them with increasingly powerful tools at decreasing cost, thus enabling new ways of working" and has, „(o)n the whole, (...) significantly improved the efficiency of information-based work." (OECD 1998, 199) With regard to the way the new information space is structured, Hitchcock et al. (1997, 2) point at the convenience of electronic links which "can be followed in an instant and will prove to be

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[3] A further possibility may be that researchers only couple their individual pieces without any deeper relation between the parts. In this case, the value-added is negligible.

orders of magnitude more productive for the user than hyperlinks in print”. In particular in the text-oriented disciplines, the availability of full-text resources is highly appreciated.

Second, E-mail and other ICT tools certainly enhanced the efficiency in contacting people, in particular among groups of researchers, but also in establishing first-time contacts or in renewing relationships. In particular, the asynchronity of E-mail has proven to be very advantageous if compared to the telephone.

At this point, there are certainly a number of problems, e.g. network reliability, stability of the computer hard- and software, incompatibilities between different file formats which all lead to frustrating additional work etc. In an optimistic view, however, these problem should soon vanish. Mittler predicts that as soon as there will be no media discontinuities any more, “academic work will be more efficient and lead to important competitive advantages” (1996, 76, translation MN; sceptical Leskien 1996).

There is however not only a pessimistic view with regard to the prospect of compatible and stable soft- and hardware, but also principled opposition to the view that CMC and ICT use leads to more efficiency. First, Hutchins argues that the use of the physical setting in which work occurs is a key to successful co-ordination of joint intellectual activity (1995, quoted by Finholt et al. 1997, 33). Hence “(c)hanging the circumstances (...) may undermine the effectiveness of the collaborative process by introducing new demands that result from loss of physical setting.” (ibid.) While under ‘normal’ conditions, tacitly shared information would be taken for granted, the need to communicate this in a cyber-environment respectively the loss of these tacit cues “may mean that collaboratory users are at greater risk of losing common ground” (ibid.) and hence be less efficient due to misunderstandings and the need for extra time of communication.

Second, the considerable more of information available at each scientist’s desk may also be overwhelming. While it seems reasonable to argue, as we will do below (2.8), that more comprehensive input might lead to at least different, perhaps even better results, there is also the filtering or selection problem. Fröhlich (1996, 10) argues that “the effects of data banks and computer networks will entail not an unburdening, but rather a further intensification of the flood of (redundant) information (and thereby an increase in information frustration), not least of all due to the greater visibility of the information flood.” For sure, there will be technological fixes to the problem in the future, e.g. knowbots or “intelligent” databases, but even the configuring and managing of these tools will cost time. Furthermore, too much inter-linked information may also lead to distraction (‘surfing around’). This is not to say that distraction and browsing may not lead to new and surprising insights, but it seems fair to say that there is a certain tendency of the new medium to seduce to inefficient time management. Rosenthal (1998) writes that “we are already running in too much duplication: hyperlinks now take one in circle; hours spent in front of screens; .... I would be first to admit that my research, teaching and professional (not to mention personal) communication has been revolutionized in the past two-three years, but I would suggest that there is a danger of it taking over completely.... The danger is that we may soon reach saturation point.”

Third, we have to acknowledge technology-related costs, e.g. the time spend on learning how to master the technology. Unfortunately, it seems, that this is not at all a one-time-investment, but a continuous process with no ending as soft- and hardware keeps changing at short intervals.

Fourth, much of the work which was outsourced in the days of the old typewriter, in particular the formatting of articles, is now increasingly done by the scientists themselves and not by the publishing houses any more. There may be a number of academics who do this quickly and easily in their intellectual “wait loops”, but others seem to spend quite considerable time on this new and demanding task, thus having less resources for the genuine intellectual work.

In general economic theory, it is all but clear whether information technology enhance productivity (Zerdick et al. 1999, 127 of online manuscript). The empirical study carried out by Riehm (1996) seems to confirm this conclusion for academic work, too: ”(T)he electronic version was used for a significantly longer period of time than the printed version, but also that utilization was less systematic. The choice of medium had little influence on the ability to reproduce the contents correctly. Thus, the popular belief that electronic information systems, in particular hypertexts, are generally more efficient was not confirmed.”

(2) Productivity of the academic system

If we now look at the systemic or macro level, there are again a number of arguments suggesting that science as a whole may become more productive through the use of ICT. First, as we have already argued above in the context of increased co-operation, CMC use may allow a more efficient division of labour. The OECD report speaks of economies of scope if barriers between sciences are broken down, but warns of the danger of over-specialisation (1998, 225).

Second, the NRENAISSANCE Committee (1994, 113) points at the efficiency-enhancing potential of sharing scarce resources, like for instance computer power or experimental instruments which can be used remotely. In this context, the OECD observes economies of scale when the work is performed with more specialists and by sharing data (ibid., 225).

Third, the OECD adds another important aspect, namely unnecessary duplication of research. The report estimates “that over 10 per cent of all research performed in the hard sciences each year had already been done” and concludes that “(p)roviding electronic access to this data source might improve scientists’ productivity by enabling them to focus on the appropriate issues.“ (ibid., 204)

Furthermore, the OECD report (ibid., 224 f.) observes time reductions for certain scientific tasks, “primarily computing, communication, data collection, and the execution of certain experiments” which may help reduce costs. This report acknowledges, however, that the evidence remained limited and that the impacts may also differ substantially among disciplines.

There are also some caveats about the positive effects on productivity and efficiency of the science system. For instance in the context of higher education, Massy and Zensky argue that so far, "most IT-based academic productivity improvements have involved doing more with more” (1995, 6), hence the net gains might not be too important. The OECD warns that ICT might not be as good in the diffusion of non-codified knowledge which is however crucial in some respects (1998, 225). ICT use may involve considerable learning costs and thus reduce the potential gains in science productivity. The OECD report concludes that ICT is unlikely to reverse overall trend of cost increases: “To some extent, ICT may simply be reinforcing patterns that were already emerging, such as joint research and the globalisation of research.“ (ibid.)

Walsh and Roselle bring in yet another aspect. Extending the “Ortega hypothesis” that the pace of science is primarily driven by those at the top of their field would suggest that “expanding the participation of those at peripheral institutions should have little impact on the pace of science” (1999, 67, referring to Cole and Cole 1972).

2.3 Time related aspects

If we look at academic communication as a package of spoken and written exchange, CMC is faster than traditional communication, in particular among collaborators in distant locations. This speed may have a number of consequences on timing in research.

First, CMC may have an impact on the necessary time to finalise projects. At least if compared to traditional international projects with no use of CMC, it seems likely that projects may become shorter due to the enhanced speed of communication and the fact that it is easier to have ad-hoc (cyber-)meetings. Bishop notes the increasing ability to complete projects on schedule (1994, quoted by Walsh et al. 1999, 66). This may allow scientific discoveries to follow more quickly one after the other (Walsh et al. 1999, 67). Or as Getz formulates: “Digital communication, then, may have its most significant consequence in accelerating the development of new knowledge.” (1997, 3) This in turn may favour more timeliness (and hence relevance?) of the projects. This was also discussed under the label “*the project that never sleeps*” (OECD 1998, 197; similar Merz 1997, 251): while asynchronous CMC may help overcoming chronological time dispersion (due to time zones), dispersion may even be seen as an advantage since collaborators may shift the research tasks back and forth (Walsh et al. 1999, 58, quoting Sudweeks and Rafaeli 1996). At least in some particular situations, this may enhance *time efficiency* – each time a researcher comes back to the office in the morning s/he may continue working on the common text on which the colleagues have worked since leaving office the day before (see e.g. Starbuck 1999, 189); in some cases it may be a conditio sine qua non (e.g. when co-ordinating astronomical projects where scanning of a particular region may be shifted from one observatory to the next).

Second, we may also ask whether increased speed of communication will have a direct impact on the outcome of the research. Or put the other way round: do some things happen because the technology is supporting them which would not be the case without the technology? These possible “things” are: increased volume of communication, more back-and-forth than hitherto, hence more revisions and, at last, better results? The obvious counter-argument here is that people would have to be prepared to engage profoundly in these new rounds of revision and refinement, and if they are not, the outcome would not be different than with fewer rounds. We argue here that while it will be difficult to establish whether or not this causal link between accelerated communication and an improved scientific outcome actually exists, it is at least likely that the result would be different than without increased communication.

Third, Merz (1997, 259 s.) argues that the advent of E-pre-print archives made the distinction between “direct” (personal contact with author), “indirect” (via libraries and mailing-lists) and “no” access to pre-prints, and hence the state-of-the-art, lapsed. Consequently, all researchers have, in principle, access to the same information at the same time. Hence E-pre-print archives *synchronise* research. This synchronising effect also leads to acceleration: since there is now a universal “time stamp” system (the registration date and time in the archive), research groups have to fear to upload their paper later than competing groups working in the same field. While in the days before E-archives there was still a realistic chance that both groups would be credited for their results, this is now less likely, because the latter group was at least in principle able to take notice of the winning groups results (ibid., 260).

2.4 Overall quality enhancement due to better fit of expertise?

We might argue that, via CMC, researchers gain access to a wider variety of projects that can make use of their skills (Walsh et al. 1999, 56). Put the other way round, project leaders may be more lucky in finding the right person for each of the sub-tasks of a project. Hence it is to be expected that the overall quality of such projects rises. Thus involving people with more specialised skills impacts on the quality and type of the research outcome.

There is also the argument that due to increased communication we may expect increased attachment to the research group and the discipline. Apart from the psychological effect on the individual level (overcoming the sense of isolation), this in turn might lead to increased commitment (Walsh et al. 1999, 59, quoting Huff et al. 1989) and hence to an overall better performance of the group in the research.

2.5 Changing methodology?

The computer has enabled new ways of doing research. First and foremost this can be observed in the formal and natural sciences, but also in the more mathematically oriented social sciences (e.g. in economics). A raising number of research questions could not be answered without the help of computing power. Furthermore, virtual reality might simulate non-human perceptions. Kircz (1998, 5) asks: “But how would our scientific intuition develop if we could equip ourselves with different sensors such as gravity sensors, that are suggested to exist in plants, the magnetic memories of sea turtles ..., or even further away, with the electric senses?” Dennett (1997, 238) writes that massive simulations are perhaps the most important epistemological progress in the scientific method since the invention of accurate time measuring devices. Coy argues that computer-based simulations and experiments became widespread in mathematics and that the digitisation replaces the traditional models (1999). The results are visualised and hence illustratively and vividly presented, thus contributing to a more immediate and perhaps deeper understanding. Coy also expounds the problems of this development. In his view, this visualisation of results makes recipients credulously believe the results and the methodology. Computer-based methods would not yet be enough challenged and analysed which would lead to a creeping devaluation of the discourse about methods. Also in the text producing disciplines, the computer has brought about considerable changes: writing on screen with all the opportunities of easy editing, moving around of chunks of text and displaying the structure of the text is a completely different experience than writing by hand or with a typewriter.

The computer network has added another dimension. First, it enabled distributed (parallel and non-parallel) computing (e.g. Berkeley’s SETI project or United Devices’ cancer research project) as well as large-scale experiments or observations not possible without a networked set of co-ordinated laboratories (e.g. in astronomy).

Second, it also gave the social scientists new tools at hand. Bainbridge observed that advanced technology is transforming the methodologies of the human-related disciplines (1999, 124) and expected that “(t)echnology for administering surveys to very large numbers of respondents over the Internet will revolutionise survey research, if appropriate techniques can be developed to compensate for non-randomness of the samples” (ibid., 128).

Third, having primary and secondary sources at your fingertips instead of having to go to the library and copy or excerpt each and every piece before you can work with it, may, on the one hand, enhance the likelihood of quoting more sources and making your own work more embedded in the work of colleagues, in particular by cross-hyper-linking. The results may become more “networked” (2.15). On the other hand, it may also lead to less original work when copying and pasting quotes into a new piece without much value added. The Internet and its much improved access to the electronic versions of texts of others may thus lead to both enhanced and diminished quality. Mittelstraß, a philosopher, argues that information technologies will not help much in the humanities (and elsewhere) since too much information, although easily accessible at one key stroke, is rather inhibitory for research than promotional because this is not the way our brain works (1996, 28 s.). Therefore he asks for the preservation of the unforeseen which is crucial for research. We think, however, that Mittelstraß is underestimating the potential of hyper-browsing through the new electronic information bases. In a similar context, Dicks and Mason argue “that since the human mind is clearly capable of making multiple linkages and connections, and since the social world itself requires flexible and multi-faceted analysis, then the creative integration of different media may offer the reader and analyst a more adequate approximation of the richness of (...) knowledge." (1998, 6.5)

Fourth, if hypermedia is used as a new form of knowledge representation one may expect, with Dicks and Mason (1998, 5.2), that (data) analysis and presentation happen in the same medium. In their field (ethnography), they distinguish between the cross-referencing approach to data analysis and the strategy of indexing. They argue that the cross-referencing approach avoids de-contextualisation and subsequent re-contextualisation of data which "potentially allows for a more embedded and holistic analytic approach" (ibid., 5.5). Their research which compared a traditional book-like approach to ethnography with a novel hypermedia approach suggested "that there may be consequences for how theoretical models are conceived once their graphical representation is no longer confined to a single-medium". Dicks and Mason are not suggesting "that there are epistemological consequences per se, since to do so would be to posit a strong form of determinism whereby thought is defined by and confined to the conventions of particular representations." They argue the opposite namely "that since the human mind is clearly capable of making multiple linkages and connections, and since the social world itself requires flexible and multi-faceted analysis, then the creative integration of different media may offer the reader and analyst a more adequate approximation of the richness of (...) knowledge." (ibid., 6.5) Also Kulchitsky and Lavoie argue that hypertext systems for case study research (2000) may bring about new, previously not possible results.

2.6 *Favouring inter- and transdisciplinarity?*

Another possible methodological consequence of ICT use is that it may be more likely that interdisciplinary work is done since it is easier to get in contact with people interested in the same subject area but looking at the issues from another disciplinary angle. One argument in favour of this hypothesis is that we can observe large numbers of issue or thematic websites which attract the attention of people regardless of their disciplinary background. Wildman, for instance writes: "Yet all the evidence today points to 'net' or 'relatio' knowledge, i.e. knowledge being generated between the disciplines. The World Wide Web with its 'hotlinks' is an excellent example of this. Clearly WWW has enormous implications for [the future university]. As it is a virtual 'relatio' host (...) Here meaning is less facts and figures locked within their respective discipline boxes and more nodes in networks of realtime web interaction. Consequently meaning is not objective, universal and fixed rather it is intrajective, provisional and partial." (1998, 628).

Expanding on this issue, we may furthermore hypothesise a relationship between the increasing communicative and information space and the type of knowledge production, in particular transdiciplinarity. Gibbons et al., in their book on Mode-2 knowledge production (1994, 10), argue that the "development of (...) information and communication technologies have created a capability which allows [the new sites of knowledge production] to interact. Mode 2 is critically dependent upon the emerging computer and telecommunication technologies and will favour those who can afford them." Or even stronger: "To function the new mode needs to be supported by the latest that telecommunications and computer technologies have to offer." (ibid., 14) Also Hitchcock et al. (1996, 9)predict that, in the longer term, "electronic publishing may be an agent to change the boundaries between academic disciplines."

2.7 *Creative chaos, interactivity and participation*

While some fear that the Internet brings chaos and less clarity, others point exactly at the creative potential of this very chaos for the research process. For instance, Gresham speaks of idea generation through written E-mail discussions (1994, 48, quoting Harasim 1990). For instance, a recent version of a sophisticated software was released which allows collaboratively and remotely to structure a brainstorming activity graphically in the form of shared “mind maps”. Another prominent writer is Harnad predicts that what he calls “scholarly skywriting” will revolutionise how science is done. He suggests that once in the electronic world “such rigorous, conventional constraints are in place, there is still plenty of room on the net for exploring freer possibilities, and the collective, interactive ones, are especially exciting.” (1993, 9) He praises the potential of “unrefereed discussion, perhaps among a closed group of specialists with read/write privileges (while others have read-only privileges)” which could be a “useful complement to conventional peer review or even to electronic adaptations of (...) editor-filtered peer commentary in the form of editor-filtered ‘skywriting’”.

Harnad argues that the shift from P- to E-publishing is not only a change of medium, but a revolution in the way science is done, namely much more interactively. ICT enables communication almost instantaneously and between “groups of individuals reciprocally, anywhere from a few collaborating colleagues, to all the experts in a given subspecialty, to an entire discipline – all just as quickly as individual email, but with the emergent benefits of the interactive feedback” (1990, 2). After describing his “vertical peer hierarchy” for scholarly skywriting, Harnad concludes that “(s)cholarly inquiry in this new medium will proceed much more quickly, interactively, and globally; and it is likely to become a lot more participatory, though perhaps also more depersonalized” (see already 2.1). Harnad argues that the individual researcher is compensated by “the possibility of much greater intellectual productivity in one lifetime” (ibid., 4).

2.8 What kind of information as a starting point

One of the most striking features of the emerging mode of doing research in the age of cyberscience is the improvement of direct access to relevant information. It is to be expected that sooner or later almost all written information necessary for research will be available online. Other material such as pictures, numerical data, audio or video files will follow suit. Our first observation therefore is that research will start with more upfront information available (on whether this efficient or not, see already above 2.2). In other words, research will be more broadly founded in the existing literature as well as empirical data. But we need also to take some potential restrictions into account.

Keyword search in databases, indexing etc. will let the cyberscientist find only what has been keyworded and indexed. How we will be “browsing” for information is about to change: we will not find any more the “book shelved next to the one we were searching for” because there are no physical shelves any more. In exchange, we might find other resources that were given the same keyword. Another interesting and previously impossible way to find even more precisely pertinent resources is full-text search. In any case, what the scholar starts with before analysing and working out a theme is changing. In some respect, it is (a bit) less, in another it is (much) more. Bourguignon agrees: “Thus it is highly likely that these databases will end up by themselves exercising a subtle and important influence on the long-term evolution of research in the field.” (1999, 113)

Mueller risks the following prediction “based on assumptions about human inertia: once the electronic literature of a discipline is sufficiently large and diverse to give scholars the sense they may have enough stuff for their project, they will be tempted not to look elsewhere” (2000, 8). This is no problem anymore as soon as most of the sources are indeed online, in some disciplines however, there is a long way to go still and this may lead to blind spots.

Another aspect of the new ICT-based way of doing science is the worldwide sharing of knowledge in so-called shared knowledge bases. In some fields, academics already contribute and have access to common databases, often managed by international networks (e.g. the HUGO – Human Genome database). There is for instance the idea of an “International Network for Integrated Social Science” which would be a “transdisciplinary, Internet-based collaboratory that will provide social and behavioural scientists at all institutions with the databases, software and hardware tools, and other resources to conduct world-wide research that integrates experimental, survey, geographic and economic methodologies on a much larger scale than previously possible” (Bainbridge 1999, 131, this is also called the “netlab” facility). Again, subsequent research is based on the wealth of previous knowledge without it being the sole responsibility of the single researcher to gather all this knowledge on his/her own. As Getz argues, the electronic information services have a power in the creation of new ideas and the digital sharing of ideas seems likely to expand the human potential significantly (1997, 21).

Increasingly, filling and structuring electronic online archives and databases also becomes the content of whole research projects. Is something like the Blake Archive[4] the endpoint of the scholarly work or rather the starting point for further research? If, in the traditional research, the main trust of the work consists of finding the sources, of arranging them, of making them available, and of transcribing them, then something like this archive is the endpoint. If, by contrast, the proper work only starts by then, if comparing, annotating, interpreting etc. is considered the main task, then the Archive is only just a starter, presenting the opportunity (to more people than hitherto) to analyse the “data”.

2.9 Choice of subject

While in the previous sections we did not question the choice of the research topic, but only how it will be treated, we shall ask here whether different subjects will be treated due to the different opportunities to organise scientific work. Do networked researchers do different things than those not working in the net? We are not talking here about the new field of Internet research (in the sense of research about the Internet); it is clear that the appearance of this new scientific subject is triggered by the emergence of the Internet and its opportunities. Instead we are interested in knowing whether researchers in all disciplines adapt their research topics according to the new possibilities of remote access and collaboration etc.

One possibility is that researchers do even more specialised research with extremely specialised colleagues (2.1). Alternatively, other researchers may chose to broaden their approach by explicitly involving experts from related disciplines who may be easier accessible than before the advent of CMC (2.6).

In the report “Realizing the Information Future“, the authors observe that “(q)ualitative benefits have arisen with changes in the nature of the work being done: broader interaction can change the questions being asked” (NRENAISSANCE Committee et al. 1994, 113). Brandtner gives us an example in the humanities: “If literature science is in a position to revert to manuscripts and autographs, then the focus of research and theory as well as methodology building will shift and reconstitute. (...) Under today’s conditions, [to provide optimal access to autographs] is only possible with the help of current information technologies. (...) The structure of the searchable categories defines also the topics of literature science.” (1998, 2055 s., translation MN)

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[4] Containing illuminated books, made accessible with sophisticated Java applets, see <http://www.iath.virginia.edu/blake/>.

2.10 Different thinking, different types of results?

This is possibly the most difficult question to tackle. How to compare unique scientific results either achieved in a traditional or a cyber-setting with the output of a hypothetical project of the opposite format? There seems to be no direct way to get empirical data on this since it is impossible to carry out a research project in two parallel experiments with the same[5] persons. Therefore, we are bound to ask researchers about their experiences and analyse the likely impact of the technology by comparing previous and current research while taking due account to the reduced comparability of the cases.

A number of writers have touched upon this theme already. Brown argues that “all remembering occurs in a given context. And this context fundamentally alters the content of what is remembered.” (1999). Translated to our subject here, ICT and in particular web archives, E-mail digests, groupware shared space and the like will impact on what researchers actually process and hence on what grounds the results are based. In some respect, the Internet contributes to a growing together of different, previously independent intellectual traditions and hence to new solutions (cf. Starbuck 1999, 190). In the report “Realizing the Information Future“ we read that “(q)ualitative benefits have arisen with changes in the nature of the work being done: broader interaction can change (...) the review accorded to research....” (NRENAISSANCE Committee et al. 1994, 113). Hence more review will make the results different, maybe more sound standing. Fuller, in the context of discussing peer review and authorship in the new medium, acknowledges “technology’s potential to shape thought” (1998, 128).

2.11 The impact of a different kind of knowledge representation on knowledge and thinking

As we have seen, how scholars communicate their research is changing. So far most electronic publishing still somehow duplicates what was already done for centuries in print and uses the Internet as a new distribution mechanism rather than as a new medium. But we can already observe novel formats of representing knowledge (e.g. experiments with hypertext). For the sake of the argument, we shall presume here that in the long run, the digital world will be perceived as a new medium instead of a delivery channel. The question we would like to raise then is whether this development will impact on knowledge and thinking. In other words: When does form impact on content?

We do not need to refer back to MacLuhan’s seminal works on general media theory. In our particular context, a number of thinkers applied his main ideas. For instance, Dicks and Mason (1998, 5.8) argue that “the nature of the final product sets the parameters of the preceding stages of research” and hence, knowing what a hypermedia environment instead of a traditional book allows “will have (...) implications for how the object of study is conceived. In particular, we can postulate that a more deterritorialised and multi-layered field of meaning can emerge as the object of study.” Or Gresham writes that the textual basis of computer conferencing “fosters the reflective and analytical cognitive skills associated with the task of expressing ideas in written form” (1994, 48). Writing about the future of the universities, Dator points at “the fact that what we think we understand about the world is entirely dependent on the models and media we use to perceive and reconstruct the world. (...) exploring the relationship between what we think with and what we think about” (1998, 617). The literature scientist Mueller (2000, 6) argues that “the scholar’s role may hover in interesting ways between author, editor, and curator”. The author may no longer want to be

[5] It would be essential to have the same researchers performing in two different ways because the impact of individuality seems very important in research.

bound by a principle of selection that favours his/her story and “may want the archive to be capacious enough to support other stories”. Guedon (1994, 2) compares E-publishing to making a film out of a novel and argues that this “generates effects that go well beyond the simple translation of a text into images”; likewise, moving text from print to a digitised medium “transforms its functionalities, the way we relate to it, and the way it is distributed and received”. Therefore, “electronic publishing brings about a distinction between the access to information and the way readers relate to it.” He concludes that, “(a)ccording to our needs, we materialize the electronic information differently and we search it or study it or recycle it in other documents differently.”

Probably, hypertexts would make a huge difference: they are not only a novel form of presenting results but the making of hypertexts may also influence the type of results to put into the “text”: modularity may force the author(s) to concentrate and focus more, to present the linkage and differences to previous and value added of the present research. Although Kircz and Roosendaal argue that “(t)echnological dynamics will clearly influence all these functions [of scientific communication], however, not conceptionally, but much more in the way these functions can be performed in the future”, they nevertheless acknowledge that it can lead to a “new architecture of scientific communication, provided this architecture is accepted by the scientific community” (1996, 4). The quoted authors think that the new architecture is something qualitatively important: “The emerging electronic tools already heavily influence the way scientists think and represent their thinking and research results.” (ibid., 7) In a later paper, Kircz elaborates further on the statement “that the form of scientific communication is an important ingredient in the development of science itself” and concludes “that changing representations will indeed induce completely novel science” (Kircz 1998, 1 and 9). Note that the changing medium may have consequences for both writing and reading: the form of the final product may not only influence the author’s thinking (reflexive effect), but may also trigger different thinking on the receiving end, i.e. the reader (forward effect).

In particular, the possibility to convey knowledge via non-text, i.e. multimedia or simulations or virtual reality, bears unheard new opportunities (Kircz 1998, 4 ff.). Kircz argues that the author of the future might be “able to simulate the various analog types of perceptions in electronic (binary) form, [while] the reader of the transmitted message can compare his/her own experience of the same sensory experiences, with the interpretation of the originator. (...) (E)lectronic publishing seen this way exten[ds] the capability to preserve the integrity of completely different kinds of information over multiple copies independent of time and place. (...) With the integration of analog information into the communications, analog information which will be the same for author (originator) and reader (consumer), scientific discourse will deepen and change.” (ibid., 5)

The cognitive scientist Harnad compared E-publishing and E-communication (“scholarly skywriting”) to the invention of speech, writing and the printing press and argues that they are revolutionary because they “had a qualitative effect on how we think. (...) All three had a dramatic effect on how we thought as well as on how we expressed our thoughts, so arguably they had an equally dramatic effect on what we thought.” (Harnad 1991, 41) Electronic skywriting could be the next revolution inasmuch as it overcomes limitations of written dialogue. His argument goes as follows:

> “The two factors mediating the qualitative effects were speed and scale. Speech slowed thought down, but to a rate for which the brain evolved specific organic adaptations. Our average speaking rate is a biological parameter; it is a natural tempo. Hand-writing slowed it down still further, but here the adaptations were strategic and stylistic rather than neurological; in writing, the brain was underutilized. Evidence for this comes from the fact that when the typewriter and the word processor allowed the pace of writing to pick up again, we were quite ready to return to a tempo closer to our natural one for speech. On the

> other hand, the constraints of the written medium are substantive, and they affect both form and content, as anyone who has tried to use raw transcripts of spontaneous speech can attest: What is acceptable and understandable in spoken form is unlikely to be acceptable and understandable in written form, and vice versa.
>
> “In a sense there are only three communication media as far as our brains are concerned: The nonverbal medium in which we push, pull, mime and gesticulate, and two verbal media – the natural one, consisting of oral speech (and perhaps sign language), and the unnatural one, consisting of written speech. Two features conspire to make writing unnatural; one is the constraint it puts on the speed with which it allows thoughts to be expressed (and hence also on the speed with which they can be formulated), and the other is the constraint it puts on the interactiveness of speaking thinkers – and hence again on the tempo of their interdigitating thoughts, both collaborative and competitive. Oral speech not only matches the natural speed of thought more closely, it also conforms to the natural tempo of interpersonal discourse. In comparison, written dialogue has always been hopelessly slow: the difference between ‘real-time’ dialogue and off-line correspondence. Hopeless, that is, until the fourth cognitive revolution, which is just about to take place with the advent of ‘electronic skywriting’.” (Harnad 1991, 42)

By contrast, Fuller, a prominent opponent to Harnad, calls him a ‘cyberplatonist’: “The Platonist’s holy grail is the frictionless medium of thought that can transcend time and space to get at The Truth. The cyberplatonist believes he or she has found the Grail in the Internet. (...) The Achilles heel of all forms of Platonism is an obliviousness of the material conditions of thought, and cyberplatonism is no different in this respect.” (1998, 125 s.) Fuller represents what he calls a ‘cybermaterialist’ point of view instead.

In any case, it seems to early to draw any definitive conclusions on this issue. It seems nevertheless safe to venture, with Hert (1997, 332), the prediction that there will be „not a simple reproduction of a given pattern in a new medium while people get used to that medium.“ As scholars only start to get acquainted with the new medium, this stage is certainly not yet reached.

2.12 Dynamics of the results

Print publications are inalterable once printed. The only way of amending or adding is by publishing subsequently an addendum or rectification or a comment – which is however not part of the current academic culture and therefore practised only very seldom. In the age of cyberscience, most academic results will be published electronically. In contrast to their printed counterparts, E-publications allow, in principle, for constant update. For instance, there may be more versions of the same document, comments or addenda may be directly linked to the original etc. This possibility may trigger a new culture of “preliminariness” with both positive and negative effects. Or, as Wildman (1998, 628) argues, the WWW produces intrajective, provisional and partial meaning.

On the positive side we may list that feedback and reactions may actually impact and be taken account of by the author. In contrast to the printed world, an author who was convinced after publication that some of the arguments or data in the paper are erroneous, may be given the opportunity to rectify the mistakes. Furthermore, even without initial errors, a paper may become incomplete if not obsolete through subsequent research. In particular authors of survey articles (and their readers) may be happy to have the chance to keep it up-to-date (cf.

Dewar 1998, 16 s.). And indeed, there are already examples of E-journals which not only allow for this constant review, but make it a core feature.[6]

On the negative side, one will have to argue that knowledge stability is somehow in danger. If there is always a chance to rectify and amend a result even after publication, there is less incentive to make the piece “water-tight” in the first place. In addition, if different versions of the same text are in circulation (and quoted), this could easily lead to less clarity and even chaos.

2.13 Enhanced transparency?

Because of obvious restrictions of “real” space in the traditional print media, the empirical data and other sources, i.e. the so-called primary information only rarely form a part of the published research results. In many cases, it may however be of great interest to have a direct look at this information as it forms the basis of the research. For instance a statistical analysis or the conclusions drawn by a historian could be better evaluated by direct reference to the material used. St. Laurent (1992) assumes that those (historians) opposed to this idea of opening up the archives “have something to hide”, they would “fear widespread distribution of the information they ‘protect’ in any but the most shrouded form”. It is certainly true that building an archive or data pool by lavishly collecting the data from various sources or by transcribing, translating and ordering old manuscripts is an achievement in itself which deserves some protection. However, in an electronic environment one can think of a number of safeguards preventing possible misuse of such an archive while at the same time serving the understandable claim of the scientific community to be able to evaluate the conclusions drawn before basing further work on them.

Apart from this intra-academic aspect, transparency has also an extra-academic side, as Morey, Binning and Combs (1996, quoted by Dator 1998, 621 s.) highlight: “The walls of the academy that previously sheltered the concepts of intellectual freedom are becoming electronic tentacles that extend into the home and the global workplace. The free exchange of ideas and artistic expressions that have traditionally been acceptable inside the classroom may not be so acceptable when other stakeholders in education can view only portions of the educational process. .... The idea of the virtual classroom and its virtual university makes the distinction between inside and outside the university community more difficult to maintain.“ Hence, transparency vis-à-vis the extra-academic world touches upon the wider issue of the relationship between science and the public since the Internet is creating a new interface between these two “worlds”. It is not unlikely that scholars are already or will be very soon aware of this new interface. Awareness of another potential public outside the scientific community may change the way the results are presented and worded.

2.14 Further standardisation?

How academic results are published is already highly standardised in the world of print. Think of the various types of scholarly writings (from the monograph to the research paper), of the formal aspects (styles of bibliographies and citations, layout of figures and tables) and of the, in some disciplines, rigorous standards relating to the structure of a scientific article. In the digital age, the fact that the documents are shared and stored in electronic format adds a new route for specific standardisation. Meta-data, i.e. machine-readable meta-information about a document, such as name of author, keywords etc., for instance are the subject of intensive standardisation (e.g. Dublin Core). Likewise, we can expect to see emerging standards of presentation in the electronic format.

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[6] For instance, the “Living Reviews of Relativity”.

In the not so distant future, digital academic publishing or, more generally, digital knowledge presentation may be very different from what we are used to now (2.11)[7]. One option is hypertext instead of linear text, i.e. a more modularised format with possibly hundreds of "modules", linked together in a web-like structure. If this development actually takes place, it is quite likely that the various hypertexts of a (sub-)discipline will grow together, will be interconnected, thus leading, in the long run, to a sort of knowledge web (Nentwich 2000). Kircz who, with his team of physicists, has invested a lot of thinking in the possible future structure of the physics article, predicts that "the fact that information can be distributed in identical form and independent of time and place forces strong needs for tools and methods to compare the various aspects of the material, hence drives to standardization" (1998, 3). Harmsze has already proposed such an elaborated structure which subdivides the article into a number of constituent parts such as a section describing the experimental setting, the data, the methodology, the results etc. Also the links between the modules are standardised and hence articles in this format will be comparable and can be easily connected (2000).

Last, but not least, XML, the emerging new (meta-)standard of "tagging", i.e. technically structuring documents for the web, will again lead to standardisation. Only if the relevant documents in a sub-discipline use the same set of XML tags, i.e. the same XML dialect, then the true potential of this powerful new tool can be fully explored. There are already a number of discipline-specific XML dialects, from MathML to the ThML (Theological Markup Language). Others explore the possibility to structure written electronic discourse over the net by proposing a DiskursML (Rost 1996).

2.15 Connectivity of research enhanced?

We may define "connectivity" of research as the fact that one piece of research has a good enough "interface" towards the rest of the relevant research, in other words that it fits well and is related to and embedded in the cumulative knowledge. In this sense connectivity makes research accessible and useful for related (parallel or subsequent) scholarly work. There is probably widespread agreement that this is a basic characteristic and requirement with a view to advancing science. Connectivity may be enhanced in an electronic environment. In particular, the quoting of sources becomes easier due to easy access to almost everything written about a subject and hence aggregated footnotes may become widespread.

Kircz notes that "in the electronic era, more than ever before, the availability of all previous scientific reporting, discussions and controversies, are available as permanent sources for referencing, inspiration and, where needed, dismissal. It also means that parts of old works can be easily integrated into new works. Hence, a new period of general information reevaluation can begin" (1998, 2 s.). One might argue that in a hyperbase environment (Nentwich 2000), texts of other researchers may shrink to chunks of texts, out of context. But this danger is probably less imminent than in the paper world because the "chunks" are still embedded in their original context and may thus be read in this context. Therefore, we believe that hypertexts will lead to greater connectivity (and transparency as argued above).

Kling and Covi bring in still another aspect of the same subject: "Scholarly publishing in books and journals, like lecture series, workshops and conferences, are forums for scholarly communications whose character can be influenced by the media of communication. With each electronic invention, many scholars hope that new media can expand authors' or speakers' abilities to reach new audiences. They hope that listeners or readers will hear new voices, or hear old voices faster or more conveniently." (1995) In other words, scholars' work

[7] So far, E-publishing is mainly a digital duplication of what is still available in print form, often trying to mimicking the same (linear) layout as the print version.

may be better suited to reach the (possibly expanding) target group. One possible emerging target group may be scholars from other disciplines interested in inter- or even transdisciplinary work (2.6).

3 Outlook

It is certainly too early to try even a preliminary assessment of the issues listed in this paper. Some of our hypotheses may prove too far-reaching, others might have been overlooked. The purpose of the project mentioned in the introduction is exactly to elaborate on these hypotheses and test them. As already mentioned, the next phase will be devoted to interview a larger number of scholars in a variety of disciplines and countries to find out more about what is really going on in academic knowledge production.

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