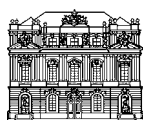


Michael Nentwich

# cyberscience

Research in the Age of the Internet

FOREWORD & EXECUTIVE SUMMARY



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## FOREWORD

For many years already, the author of this book, like many of his colleagues, has been spending a considerable share of his time staring at computer screens. He has been surfing the Web, sending E-mails, contributing to online discussions, designing homepages, filling databases, editing an E-journal and working with files stored on a server located 1000 kilometres away. Many of us may be called proto-cyberscientists. But only a couple of years back, the world was different. For sure, we already had computers, but in order to print out a text, we had to store the file on a floppy diskette, take it to the other end of the Institute and use a different PC connected to a local printer. We had no E-mail, not to speak of the WWW. Is this not a remarkable development in a single decade? The difference can be felt every day. But what exactly is this difference? How can we describe it? Is there not something beyond the surface of using just a more convenient, faster channel of communication? Do we have to expect that science will not be the science, as we have known it for the last century, once the new technologies have replaced what was there before? Will they replace it at all? Will the printed book and the face-to-face meeting become a souvenir of the past? And what will this mean for the content of research?

These questions stand at the outset of this study. The book started off as a small explorative study on the prospects of E-publications but soon developed into a multidimensional research project. It turned out that publishing is but one area where the new technologies have changed the world. Publishing, in turn, is but one area of scholarly activity. Therefore, I needed to look into neighbouring areas like collaboration in science.

Many contributed in one way or the other to the successful termination of this project. I cannot list them all, but my special thanks go to the following institutions and persons: the Austrian Research Fund (FWF) for partial funding under contract no. P 14042-INF; my home institution, the Institute of Technology Assessment (ITA), in particular to its director, G. Tichy who encouraged me to immerse myself in this fascinating topic, who discussed with me various drafts and who facilitated my work in every possible respect, as well as to all my colleagues there who were prepared to discuss earlier versions, in particular G. Aichholzer, J. Cas, W. Peissl, H. Torgersen and R. Winkler and all others who debated with me during internal seminars and coffee breaks; the Max Planck Institute for the Study of Societies (MPIfG) in Cologne and its directors for hosting me from October 1998 to September 1999 and many individual weeks after this initial year until spring 2003, and for multiple support in computer matters – I was probably one of their most demanding clients – and linguistic problems, and in particular R. Werle, V. Leib and S. Hilbring for comments, feedback and discussions; the Austrian Academy of Sciences (AAS) and its publishing house for taking this bulky manuscript on board; L. Warenits for language checking and M. Kaitna for layout and typesetting; the many interviewees who gave me their time for lengthy interviews, in particular those who even found the time to give me further feedback on a draft of chapter 3; M. Balgarensky for writing the link software EUROLINK and S. Schwarz-Esser for the hypertext script DISKURS; the discussants at the conferences *Publizistik 2000* Vienna, *IPSA 2000* Québec City, *APSA 2000* Washington, *1<sup>st</sup> IBLC 2000* Frankfurt, *INST 2001* Reichenau, *SSTNET/ESA 2001* Helsinki, *WissensWert 2002* Berlin, *AoIR 2002* Maastricht and various other occasions where I had the opportunity to present earlier drafts of texts which later became the basis of sections in this report; and U. Felt for commenting and supporting this project at the University of Vienna.

Last, but not least, I have to say a very special thank you to G. Falkner because without her continuous intellectual, as well as psychological support, her devotion in debating tricky issues and her time in discussing various early versions of this manuscript, this book would never have been finished.

**Michael Nentwich**  
Vienna/Cologne, summer 2003

## EXECUTIVE SUMMARY

For two decades already, the scholarly community has witnessed a considerable increase in the use of information and communication technologies (ICT). As opposed to “traditional” science that does without networked computers, the notion of “cyberscience” captures the use of these ICT-based applications and services for scientific purposes. The basic assumption of this study is that ICT use impacts on the basic parameters of how academia is organised, of how it functions, and of what it produces. Cyberscience will be different from traditional sciences.

Therefore, the basic aim of this study is five-fold: (1) to describe and analyse the use of ICT in the academic world (status quo); (2) to explain the status quo based on an analytical model; (3) to draw a realistic and differentiated picture of probable future developments (trend extrapolation); (4) to assess the impact of ICT on various aspects of academic activity and on the substance of research (impact assessment), as well as (5) to discuss the implications for research policy and the steering mechanisms within the scholarly organisations.

To achieve these aims, the study is organised in four main parts. The first part gives an overview of the contents, the methodology, and the conceptual framework of this study. The second part sets the scene by initially presenting the array of new ICT applications relevant to the research communities; it then studies how the various (sub-)disciplines deal with the new opportunities and analyses the present differences among the academic disciplines. The third part is the longest for it discusses the actual and potential consequences of ICT use in academia in six main areas: how it impacts on the spatial dimension of academia; on roles; on knowledge representation; on publishing in general; on quality control; on the economic and legal sphere; and finally on the substance of research. The final part discusses policy options and draws overall conclusions.

Chapter 0 argues that there are innumerable articles in a broad variety of fields dealing with some aspects of the phenomenon “cyberscience”, but that an encompassing study synthesising our knowledge of the status quo, the trends and the impact of ICT use in academia is lacking. The present study fills this gap, based on both the traditions of science and technology studies (STS) and technology assessment (TA). The study is in essence explorative and predominantly qualitative (rather than quantitative) research. It is informed by four main sources: the existing literature, 50 in-depth expert interviews, an extensive Internet enquiry and a number of practical tests of the new tools.

Chapter 1 lays out the conceptual framework guiding the analysis in the rest of the study. The model of impact of ICT on academia describes the routes on which the technology influences the scholarly communication system, academia as a whole, and finally the substance of research. Included in the impact model is a second model of ICT-induced change of the scholarly communication system that focuses on the evolution from the traditional pre-ICT state to the status quo and further to the possible future state of cyberscience. It describes the intervening factors on the institutional, actor-related and technical-functional levels that play a role in this development.

Chapter 2 is the technical presentation of the new tools and the new working environment. I distinguish between machine-to-machine, people-to-machine and people-to-people communication and describe the various elements of cyberscience-in-the-making, from distributed computing and knowledge robots to interactive reading devices, digital

libraries, remote control technology for virtual laboratories, and E-publishing. Additionally, the technical options for digital archiving are discussed.

Chapter 3 is devoted to the description and explanation of the status quo of the use of cyberscience tools in thirteen academic disciplines. Based on small case studies of the (sub-)disciplines, I present a cross-disciplinary comparison of the status quo. The resulting picture is colourful and does not support some of the most common prejudices. For instance, there is no general cleavage as regards natural sciences versus humanities. In fact, the field that turns out as the most advanced among all sub-disciplines included here is history. The last part tests a number of hypotheses that may explain the differences between the fields under scrutiny. It turns out that none of the variables included can explain all variety, but instead the status quo is the result of a complex web of multi-causal relationships.

Chapter 4, the first of a series of chapters focussing on the potential impact of ICT-use in academia, is devoted to the spatial dimension of academia. Key issues such as the suitability of E-mail for academic communication, the prospects of virtual seminars, and the role of multimedia are discussed. I analyse impact under the headings of distant collaboration, enhanced efficiency, written culture, academic infrastructure and virtual scientific communities. In sum, space, that is the geographical distance between researchers and between them and their facilities (offices, resources, libraries etc.), diminishes in importance. Other dimensions are increasingly essential in shaping the circumstances under which research takes place. The overall conclusion is that the future of academia is by no means complete “de-materialisation”, but will be characterised by a new balance of both material and immaterial elements.

Chapter 5 discusses ICT-induced role changes in academia. Scholars have to acquire new skills and perform new roles, and the role of teaching is altering with the coming digital age, too. Librarians are becoming “cybrarians”, that is information brokers, digital consultants and information managers of digital information. Also the publishing sector is changing dynamically with a reconfiguration of the respective roles of scholars, libraries, agents, and publishing houses. Discussing the democratisation thesis, I come to the conclusion that there are good arguments both for and against a weakening of hierarchy in academia. Peripheral researchers will in some respects be better placed vis-à-vis the top scholars, but in general still not on an equal footing.

Chapter 6 analyses the potentials of new forms of knowledge representation in academic publishing, in particular, digitisation, multimedia, new forms of visualisation, and hypertext. A number of advanced scenarios are constructed which speak, inter alia, of thematic hyper-databases that collect and represent available the state-of-the-art of a speciality. The impact assessment of this possible future focuses on the changing character and type of texts, the effects on authors, the readability of digital media, and scholarly communication as a whole. I conclude that while some of the elements of this future are already well established, many elements are still missing. My analysis of the likelihood of the scenarios revealed that the crucial issues lie in the institutional realm. In particular, it will be a matter of overcoming institutional inertia and of setting the respective incentives with a view to realising the full potential of the digital age.

Chapter 7 considers the future of academic publishing as a whole. The status quo is described as a mix of print and electronic publishing as well as some hybrid forms. The potentials of E-publishing reach from speeding up academic publishing to innovative formats. The main potential impact of the advent of ICT in academic publishing discussed in this chapter is whether and when there will be an end to paper-based publishing. I dis-

cuss this separately for the various scholarly publishing formats and come to the conclusion that E-publishing is likely to dominate the future of academic publishing to a large degree. Only for some special purposes, will print publications survive as the functions of the scholarly publication system can be equally or even better fulfilled via electronic means. Maybe the most important qualitative change ahead of us is the advent of a mixed-mode communication. The new mode will provide for two-way or multi-way communication as opposed to unidirectional dissemination. In addition, I discuss in this chapter the issue of digital archiving from an organisational perspective, and conclude that important decisions have to be made quickly.

Chapter 8 addresses the hotly disputed issue of quality in the digital age. Starting from an analysis of the present system of academic quality control, I discuss the new developments and opportunities. Inter alia, there are new forms of ex-ante control as well as innovative forms of ex-post control. Discussing the path to a certification system adequate to cyberscience, I refute the often-heard argument that E-publishing would necessarily lead to less quality, and submit a scenario of re-establishing and reforming peer-review for E-publishing, including quality labelling. Finally, I analyse challenges for the established system of credentialing in academia. As ever more scholars are publishing online or even investing in new forms of cyber-publishing, review and tenure boards are facing the decision whether and how to give credentials for the new formats. I conclude that the further evolution of certification and credentialing systems in the various disciplines would probably not be synchronous. Inter alia, this depends on whether there will be a shift in the academic culture towards more quality and communication as opposed to more quantity.

Chapter 9 addresses two inter-linked areas of ICT-induced impact, namely economics and law. First, I compare electronic and print publishing and find that the former is indeed much cheaper, in particular in the longer run. Then I look at the academic publishing system as a whole and find that it has been in a state of permanent financial crisis since about a decade ago. While commercial journal publishers make high profits and university presses cannot afford to print highly specialised literature any longer, academic libraries have to cut down their purchases. E-publishing, organised from within academia, proves to be a likely solution to these problems and is discussed under the label of “de-commodification”. Second, I discuss the various legal aspects of academic cyber-publishing, in particular copyright issues. I conclude that the traditional, paper-based intellectual property rules are hardly coping with the new situation in a digitised environment. However, the current legal developments have to be analysed critically as stricter rules may endanger the mission of academia because researchers are highly dependent on free access to information.

Chapter 10 searches for an answer to the question whether ICT-induced changes of the scholarly communication system have the potential of impacts on the substance of research. Three possible routes of impact are detected, namely via changes of methodology, of work modes, and of knowledge representation. A number of hypotheses in these three areas are discussed and the conclusions are supported by evidence from my empirical research, in particular the interviews. Here, I find, categorise and assess a number of potential effects. I conclude, however, that it is impossible at this point in the development of cyberscience to go beyond a list of potential and likely developments. While a noteworthy potential to impact on the substance of research is certainly there, it waits to be realised, and no detailed predictions are feasible at this stage.

Chapter 11 outlines the politics of cyberscience, its arenas, actors and overall issues. The most salient issues are discussed in detail. These include the need to provide an adequate cyberscience infrastructure and universal access to it; to establish a secure, trustworthy and stable E-publishing environment, including the solution of digital archiving and the adaptation of copyright to the needs of cyberscience; and to engage in information management, that is the technical-organisational infrastructure necessary to cope with the growing digital information plus adequate training. Based on this discussion, the final section lists policy recommendations for the main groups of policy actors.

Chapter 12 contains the overall conclusions of this study. The main part is devoted to an overall cyberscience scenario, carefully pulling together the various tentative forecasts made throughout this book, followed by meta-level conclusions about cyberscience as a whole. A short Coda puts this study into perspective by discussing the usefulness of my conceptual framework, by listing a number of scope conditions, and by proposing a few routes for further research.

An overall conclusion of this study is that we are in midstream of a forceful development. Cyberscience is already taking place, but will develop its full shape and potentials only later. The new media have only just begun to play a central role in a large array of scholarly activities, and in regard to the institutional setting. Not only academic communication in the narrow sense, but also the distribution of knowledge and, most importantly, even knowledge production are affected. Hence, the impact of information and communication technologies should not be underrated. At this point, well-considered, but only preliminary conclusions can be drawn. Consequently, scholarly attention to this important phenomenon should by all means grow.