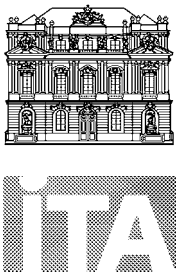

CYBER.SCIENCES

THE FUTURE OF ACADEMIA IN THE @GE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

ENDBERICHT (AUSZUG)

INSTITUT FÜR TECHNIKFOLGEN-ABSCHÄTZUNG
DER ÖSTERREICHISCHEN AKADEMIE DER WISSENSCHAFTEN

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Bitte beachten:

Dieser Projektbericht wird demnächst als Buch erscheinen. Daher wird der gesamte Text vorläufig nicht der Öffentlichkeit zugänglich gemacht. Der folgende Kurzbericht gibt einen Überblick über den Gesamtbericht und beinhaltet insbesondere das Executive Summary. Wir bitten um Verständnis.

Please note:

This project report will soon be published as a book. In the mean time, the full text will not be made available. The following short report gives an overview of the full report and, in particular, the executive summary. We hope for your understanding.

Project homepage:

http://www.oeaw.ac.at/ita/cyberscience.htm

Link collection:

http://www.oeaw.ac.at/ita/cyberlinks.htm

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2 Kurzfassung

Die Studie „Cyber-Wissenschaft“ untersuchte die Auswirkungen des Einsatzes der neuen Informations- und Kommunikationstechnologien auf die Wissenschaft. In einem ersten Schritt wurde der Status Quo erhoben. E-mail wird nahezu flächendeckend eingesetzt und Online-Datenbanken sind weit verbreitet. Während E-mail-Diskussionslisten teilweise als sehr bedeutend eingeschätzt werden, sind Internet-Videokonferenzen vorläufig noch die Ausnahme. Virtuelle Forschungsinstitute gibt es zwar erst in Ansätzen, aber die Tendenz zeigt nach oben. Elektronische Zeitschriften, Volltextdatenbanken für digitale Arbeitspapiere, ebenso wie digitale Bibliotheken sind ebenfalls auf dem Vormarsch. Insgesamt wurden Fallstudien zu 13 wissenschaftlichen Fächern erarbeitet und miteinander verglichen. Entgegen erster Erwartungen, sind es keineswegs nur die Naturwissenschaften, die neue Technologien verstärkt einsetzen. Auch einige geistes-, sozial- und kulturwissenschaftliche Gebiete, wie etwa Teile der Geschichtswissenschaften oder etwa die Papyrusforschung, sind in dieser Hinsicht sehr fortschrittlich.

Das Forschungsprojekt hat in einem zweiten Schritt umfassend untersucht, welche Auswirkungen der Einsatz neuer Medien schon heute hat und welche in Zukunft zu erwarten sind. In der Cyber-Wissenschaft werden räumliche Distanzen (etwa zu Bibliotheken) weniger bedeutend sein. Forschung abseits der Zentren wird in gewissem Umfang einfacher werden. Vor allem im Bereich des wissenschaftlichen Veröffentlichungswesen zeichnen sich grosse Veränderungen ab. Elektronisches Publizieren wird in der Wissenschaft in nicht allzu ferner Zukunft das Papier fast vollständig ablösen. Neue Qualitätssicherungsverfahren sind im Entstehen und werden die bestehenden ergänzen. Neue Formen der Wissensdarstellung (Hypertext, Multimedia) könnten bald an die Seite des klassischen wissenschaftlichen Buchs oder Artikels treten. Darüber hinaus eröffnet das deutlich billigere elektronische Publizieren die Möglichkeit, dass die Wissenschaft sich von den finanziellen Belastungen durch das privatwirtschaftlich organisierte Veröffentlichungswesen befreien könnte. Im Urheberrecht besteht dringender Handlungsbedarf um sicherzustellen, dass Wissenschaft weiterhin den unabdingbaren Zugang zu allen wichtigen Informationen hat. Die Studie stellt abschliessend auch ein grosses Potential für indirekte Auswirkungen selbst auf die Inhalte der Forschung fest. Die elektronischen Medien ziehen Veränderungen in der Methode, den Arbeitsweisen und Darstellungsformen des Wissens nach sich, die sich auf die Wissensproduktion auswirken.

3 Abstract

The study “Cyberscience” analysed the impact of information and communication technologies in academia. In a first step, we collected data on the status quo. E-mail is used practically universal and online databases are spread very widely. While E-mail discussion lists are partly considered very important, Internet video-conferencing is, so far, the rare exception. Virtual research institute exist only to some extent, but there is a trend to more. Electronic journals, full text databases for digital working papers, as well as digital libraries are gaining ground. Altogether, we elaborated and compared 13 case studies of academic disciplines. Contrary to expectations, not only the natural sciences use increasingly these new technologies. Also several fields in the humanities, social sciences and cultural studies, such as parts of history and papyrology, are well advanced in this respect.

In a second step, we analysed in-depth what kinds of impact the use of new media already has today, and which effects are to be expected in the future. In cyberscience, spatial distances (e.g. with regard to libraries) become less important. Peripheral research distant to the centres will be easier to some extent. In the field of academic publishing, in particular, important changes are looming. In academia, electronic publishing will replace print and paper in the not so distant future. New procedures of quality control are in the making and will complement the existing ones. New formats of knowledge representation (hypertext, multimedia) are likely to be seen soon next to the classical scientific article or book. In addition, the much cheaper electronic publishing opens up the opportunity that academia gets eventually rid of the financial burdens that are laid upon it by the present commercialised publishing system. As regards copyright law, there is urgent need for action in order to guarantee research the necessary access to all important information. Finally, the study found that, potentially, there will be even indirect impact on the substance of research. The electronic media trigger changes in methodologies, work modes and as regards the representation of knowledge. These changes may have an impact on knowledge production.

4 Executive Summary

information and communication technologies impact on the basic parameters of science and research

For two decades already, the scholarly community witnesses a considerable increase in the use of information and communication technologies (ICT). As opposed to "traditional" science which 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 science.

five aims of the study:

- *status quo*
- *analysis*
- *trend extrapolation*
- *impact assessment*
- *policy recommendations*

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.

overview of the four parts of the study

To achieve these aims, the study is organised in four main parts. The first part gives an overview on 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 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 concluding part discusses policy options and draws overall conclusions.

this report synthesises our knowledge of the status quo, the trends and the impacts of ICT use in academia

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 & 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.

50 expert interviews

the conceptual framework:

- *modelling impact*
- *modelling change*

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 which 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.

the new tools, the new working environment

Chapter 2 is the technical presentation of the new tools and the new working environment. We distinguish between machine-to-machine, people-to-machine and people-to-people communication and describe the various ele-

ments 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.

status quo in 13 disciplines:

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, we present a cross-disciplinary comparison of the status quo. The resulting picture is colourful and does not meet some of the most common prejudices. For instance, there is no general cleavage as regards natural sciences versus humanities. In fact, the field which comes out among all sub-disciplines included here as the most advanced is history. The last part tests a number of hypotheses which 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.

no general cleavage as regards natural sciences versus humanities

the spatial dimension of academia:

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. We 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 in 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.

no complete "de-materialisation", but new balance of material and immaterial elements

role changes in academia:

- ***new skills***
- ***"cybrarians"***
- ***outsourcing***
- ***advantages for peripheral researchers***

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, we 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.

new forms of knowledge representation:

hypertext and multimedia

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. We conclude that while some of the elements of this future are already well established, many elements are still missing. Our 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 realise the full potential of the digital age.

overcoming institutional inertia is crucial

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 to innovative formats for academic publishing. 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. We discuss 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, print publications will 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-, or multi-, way communication as opposed to unidirectional dissemination. In addition, we discuss in this chapter the issue of digital archiving from an organisational perspective, and conclude that important decisions have to be taken fast.

potentials of E-publishing:

- ***speed***
- ***innovative formats***

Academic print publishing likely to disappear

important decisions have to be taken as regards archiving of digital material

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, we 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, we 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, we analyse challenges for the established system of credentialing in academia. As ever more scholars publish online or even invest in new forms of cyber-publishing, review and tenure boards face the decision whether and how to give credentials for the new formats. We 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.

new forms of quality control: ex-ante and ex-post

E-publishing does not necessarily lead to less quality

certification and credentialing in the various disciplines will not be synchronous

Chapter 9 addresses two inter-linked areas of ICT-induced impact, namely economics and law. First, we compare electronic and print publishing and find that the former is indeed much cheaper, in particular in the longer run. Then we look at the academic publishing system as a whole and find that it is in a state of permanent financial crisis since about a decade ago. While commercial journal publishers make high profits and university presses cannot afford any longer to print highly specialised literature, 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, we discuss the various legal aspects of academic cyber-publishing, in particular copyright issues. We 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 critically analysed with a view to avoiding that stricter rules endanger the mission of academia because researchers are highly dependent on free access to information.

E-publishing is cheaper

E-publishing may help solving the financial crisis of academic publishing

"de-commodification"

current legal developments may endanger research

potential to impact on the substance of research via changes in:

- ***methodology***
- ***work modes***
- ***knowledge representation***

Chapter 10 searches for an answer to the question whether ICT-induced changes of the scholarly communication system have the potential to impact 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 our empirical research, in particular the interviews. We find, categorise, and assess a number of potential effects. We 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 awaits to be realised, and no detailed predictions are feasible at this stage.

most salient policy issues are:

- ***infrastructure and access***
- ***stable and trustworthy E-publishing environment***
- ***information management***

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.

overall cyberscience scenario

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 our conceptual framework, by listing a number of scope conditions, and by proposing a few routes for further research.

cyberscience is already taking place

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 as regards 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, only preliminary conclusions can be drawn. Consequently, scholarly attention to this important phenomenon should all but stop.

impact should not be underrated