Research & Occasional Paper Series: CSHE.6.03

CSHE Center for Studies in Higher Education

UNIVERSITY OF CALIFORNIA, BERKELEY
http://ishi.lib.berkeley.edu/cshe/

VIRTUALIZATION OF RESEARCH UNIVERSITIES: RAISING THE RIGHT QUESTIONS TO ADDRESS KEY FUNCTIONS OF THE INSTITUTION*

May 2003

Thomas Pfeffer
Researcher
Hochschulforschung | Higher Education Research
IFF - Institute for Interdisciplinary Studies at Austrian Universities

ABSTRACT

The aim of this paper is to provide an overview of the variety of information and communication technology (ICT) applications at traditional universities and to integrate them into a holistic picture of the institution. Using the distinction of three key elements of scholarly activity (research, publication, education), it suggests a functional perspective of the organization as a way to raise questions for the assessment of ICT applications in universities. This may lead to a better understanding of the different rationales in research, publication, and education. Acknowledging these differences might enable finding ways for using ICTs to foster academic productivity in each of the different aspects separately and also for contributing to their integration in the organization of the university.

1. Introduction

The popular expression “virtual university” is widely used for a vast variety of phenomena (Baumgartner 2000). Some use this label for institutions that merely put their course catalogues online, some for universities that offer online materials for traditional courses or even a few online courses within otherwise traditional curricula. In other cases, the term is used for web-based umbrella organizations that cover online

* This paper is based on research performed during my visit at the UC Berkeley, which was partially supported by the CSHE grant program Higher Education in the Digital Age.

activities of some higher education institutions, for alternative providers of higher education, or even for organizations that merely act as brokers for online courses or curricula. Also a very few institutions have specialized in exclusively providing online distance-learning higher education. This variety of phenomena to which the term is applied results in a confusing picture of what a “virtual university” might be. Additionally, the term is commonly used with a strong bias towards education, often reducing e-learning to web-based education, while simultaneously neglecting other activities of traditional research universities, which go far beyond higher education. And, last but not least, the term suggests something similar to an ultimate state of an ideal organizational form that nobody has yet clearly envisioned, but which all higher education institutions will have to resemble in the near future. As Harley (2002) observes, information and communication technologies (ICTs) are frequently regarded as promising solutions for a triad of pressing issues (costs, increasing access, and quality), while clear reference models are missing.

These limitations are not only unsatisfactory from a theoretical point of view; they also might mislead practical choices for the implementation of ICTs, if education is de-coupled from other activities at the university and designed around technology, while ignoring the possible coherence with other key functions of the university. To avoid some of these limitations, it seems to be more appropriate to speak of a “virtualization” of universities, indicating that the introduction of ICTs is not a deterministic, but a long lasting, evolutionary process, that meets with the tradition of old institutions. To overcome other definitions, it will be necessary to open the narrow focus and to gain a more holistic view on the use of ICTs in research universities, comprising the relationship between education, publication, and research.

2. Three elements of scholarly activity

Noam (1999b) distinguishes three major elements of scholarly activity: the creation of information, the preservation of information, and the transmission of information. Additionally, he claims that the dominant organizational model for universities and their predecessor institutions has been the central storage of information. According to this idea, universities have worked as local accumulations of scientists, books, and students. Noam claims that new ICTs challenge this model, which in the long run could endanger the (monopolistic) status of universities in society and, as a consequence, their funding basis. Therefore he predicts a dim future for the university (Noam 1995). Others have joined him in this forecast, for example, Drucker (1997): “Thirty years from now the big university campuses will be relics. Universities won't survive.” Before we discuss the validity of Noam’s arguments, we will use his categories to guide our observations. Do we really find ICT in all of the three key elements of scholarly activity, in the:

- *Creation of information* (commonly known as research),
- *Preservation of information* (commonly known as publication and archiving),
- *Transmission of information* (commonly known as education)?

3. Creation of information: The impact of ICTs on research

According to Nentwich (1999), all forms of research activity are affected by ICTs. He distinguishes between the following aspects: data sources, data mining and analysis, data generation, data administration and representation, as well as scientific

communication and collaboration. We will describe his categories and enrich them with examples:

- *Data sources:* One outcome of the ICT-revolution is the fact that new data sources are made available for researchers, or better, that data sources are given a new form. Data banks for basic material such as legal material or statistical data are a prominent example of this. Another is virtual libraries, which in their first step only consist of the metadata from (research) texts, which are made available via an electronic catalogue. In a further stage of development, they also contain full texts. Digitized data sources revolutionize scientific work in several ways. One major way is in terms of access in that more information becomes available for the single researcher. This tendency is accelerated by intense efforts to standardize digital formats for scientific data sources and to interconnect them.

- *Data mining and analysis*: Another effect, which is closely linked with the digitization of data sources, can be found in new possibilities for data mining and data analysis. Simple search engines increase the speed and extent of investigations into digital data sources. “Knowbots” (knowledge robots) are little software tools that can be programmed to automatically and periodically search the net. One example for this was the online service Paperboy [W1], which automatically delivered individualized newspapers for specifiable profiles of interest, which were composed of articles from online newspapers and archives. (An ongoing lawsuit involving a leading publishing company in Germany has currently stopped the service.) While these examples only describe various forms of search functions, data transformation and analysis goes a step further. Simple examples are programs for statistics or text analysis that create new links and correlations. Even more advanced are expert systems that automate complex parts of the process of arriving at scientific conclusions. Maybe the most prominent example from the live sciences is the Human Genome Project [W2], where the analysis of the human genome was made possible through the automation of analyzing routines. Trow (2002) observes that “[t]he first analysis of ... the human genome is a triumph of computer science, without which these tremendous discoveries could not have been made in our lifetime.”

- *Data generation:* A very diverse type of research activity is data generation, which differs considerably among the disciplines. Pioneers are the natural sciences, which have already been using computers for a long time, e.g., for calculations, modeling, and simulations. In the meantime, some larger research projects (e.g., in mathematics or astronomy) are only possible with the joint use of calculating capacity in “parallel super computing networks.” During the past decades, all the other disciplines have also been increasingly influenced by ICTs. Economics, for example, uses them for complex model building and the social sciences develop new methods of research such as email surveys and online investigations.

- *Data administration and representation:* Even if the concept of the “paperless office” is far from becoming reality (instead, the use of the computer increases the general consumption of paper), ICTs have also influenced researchers’ administration of their own individual data. There are vast qualitative differences between the simple storage of data on a (individual or joint) hard disk and the more complex integration of data into (individual or joint) data banks. Most scientific data are put in a digital form, which makes it easier to transfer them from one production process to another.

Important for this development are changing techniques for representing data and information. A first step in this direction was the use of computers for digital word processing, later for so-called desktop publishing. Both functions still aim at a hard copy as the final product, but greatly alter the method of production and produce a digital form as a by-product. This relationship changes with the introduction of hypertext and multimedia; the digital representation of information becomes the main product. Hard copies are still possible and necessary, but will soon be reduced to the status of a by-product.

- *Scientific communication and collaboration:* Email is the most common use of the Internet and it is the basis for more complex applications such as mailing lists and newsgroups. It is one of the main motivations enabling asynchronous collaborations (e.g., on joint articles), even across long distances. Synchronous online interaction can take place in chats or online conferences. Scientific collaborations can lead to the foundation of virtual groups or virtual organizations and can be supported by the use of small groupware such as Basic Support for Collaborative Work [W3] or by bigger content management systems, which have the potential to construct or rebuild entire organizations electronically. In principle, these systems offer a virtual space in the Internet for the storage of electronic materials and tools for various kinds of interaction in a limited community, both of which can be accessed anytime from any place.

It is possible to complete Nentwich's range of categories by adding the following two types of phenomena:

- *Integration of formerly distinct research activities:* New ICTs not only change single research activities, but based on the isomorphy of a common digital code they also offer new opportunities to re-arrange and integrate formerly distinct research activities. An example of this can be found in the convergence between word processing software and reference management tools such as Endnote [W4], where the electronic archive for references can be linked with citations in a document to automatically generate a bibliography.

- *Development of academic disciplines:* ICTs not only change the form of scientific production, they gain increasing influence in research agendas and in the development of academic disciplines. The pace of technological innovation makes it more necessary than ever before to match research focus with infrastructure, since the selective use of ICTs can be crucial for the success of any research activity. This puts an enormous strain on the financial resources and, even more so, on the decision making capacities of every scientific organization. On the other hand, ICTs themselves become a prominent research topic, which even leads to the development of new sub-disciplines (e.g., Computer Sciences, Economics and Computer Science, Multi Media Art, etc.) and to the foundation of new academic units (e.g. Berkeley Multimedia Research Center [W5]; University for Health Informatics and Technology Tyrol [W6]). Even more interesting is the fusion of a former support unit with an academic department at the University of Graz (the ICT support unit for the Faculty of Humanities was integrated into the Institute for Informatics in the Humanities, a new academic unit, formed as a replacement for the former Institute for Basic Research in History (Höflechner 2002). This unit can serve as an example of the blurring boundaries between technical and academic expertise.

4. Preservation of information: The impact of ICTs on publishing and archiving

4.1. Preservation of information through publishing

Some authors experience extreme costs for producing digital material (especially when multimedia is included), but also have good chances for obtaining enormous profits in the digitization of scientific publications. Quoting Michael Milken (a major investor and the former "junk-bond king" of Wall Street in the 1980s), Noam (1999a) suggests that "Higher Education is a trillion dollar business run by amateurs." In his opinion, ICTs have the power to push higher education from a handcraft to industrialized production, comparable to the impact the audio-disk had on the music market. Therefore, he sees an ultimate threat to universities coming from commercial publishers, who have experience in the commercial production and distribution of knowledge-based material. They could be able to provide online mass-education for lower *per capita* costs, which in the long run would endanger universities' funding basis.

A completely different perspective comes from Harnad (1999), who claims, that researchers have always only been paid for their research, but "never got a penny for the reports of their research findings." The consumer (e.g., reader, library) of a scientific publication merely paid for the costs of printing and dissemination. Scientists were interested to reach a big audience, not for direct financial profit, but to increase the impact of their work and to raise their reputation as scholars. Making scientific information available to everybody who is interested for debate and further development is part of the intrinsic logic of scientific communication. Therefore, he claims, in principle scientific publications are "give-away" literature, distinguishing it from "non-give-away" literature, which is sold to make a financial profit.

This sharp distinction becomes extremely relevant with new technologies, since they reduce the costs of digital reproduction of scientific presentations to almost nothing. As a consequence, he suggests that all scientific publications should be stored in de-centralized online archives and made available to everybody for free. "So authors should transfer to their publishers all the rights to sell their papers, in paper or online, but they should retain the right to self-archive them online for free for all" (Harnad 1999, p. 6).

This suggestion sounds a bit idealistic, but it works well with the basic idea of the Internet and the intrinsic motives of the individual scientist as well as of the entire scientific community. More convincing than these theoretical considerations are examples where the concept of the free online archive for scientific publications has already been realized. One of the largest initiatives in this context is the Los Alamos Physics Archive [W7] in which over 100,000 papers in physics have been self-archived by their authors since 1991. But Los Alamos will be surpassed by the Public Library of Science [W8]. This is an initiative that advocates a free online library for research in medicine and the life sciences. Up to now, about 30,500 scientists have signed an open letter stating that from September 2001 onward, "the signatories will only publish in, edit, or review articles for journals that grant free distribution rights six months after they are published" (Davis 2001).

While Harnad only advocates free access to traditional forms of publication, such as reviewed scientific journals, the last, most thrilling example by far exceeds his comparatively humble suggestion. In April 2001, MIT announced its commitment to

invest $100 million during the next 10 years in its OpenCourseWare [W9] initiative, planning to create online material for almost 2,000 courses and to make this material freely available on the World Wide Web for noncommercial use (Goldberg 2001). Very clearly, OpenCourseWare, which acts in line with the principles of the Open Source Initiative [W10], challenges attempts to privatize scientific knowledge and is a big blow to business models, which are based on expected profits from commercial courseware.

But what is the main rational of MIT's OpenCourseWare, if it is not for direct financial profit? Learning from the computer industry, where closed, proprietary software systems increasingly become a hindrance for further progress, MIT came to the following conclusion: "Higher education must learn from this. We must create knowledge systems as the new framework for teaching and learning" (Vest 2001, p. 3). This position is not a sign of mere altruism, but a bold act of leadership, which will strengthen MIT's presence as a global player in the research community. OpenCourseWare, which is more a form of academic publishing than of teaching, makes course material available to a far broader audience than traditional ways of dissemination, something that seems to be widely appreciated by MIT's faculty (MIT News 2001). In other words, MIT's OpenCourseWare initiative can be seen as a massive investment to attract the scarce resource of attention, an important strategic move in an "economy of attention" (Franck 1999).

Publishing is the scientific way to attract attention, not only of an individual, but also at an institutional level. Hunter (2001), who compares the involvement of universities in the current electronic publishing revolution to their role in the publishing revolution of the fifteenth century, therefore argues that since the advent of the Internet Web services have to be understood as the technical and cultural equivalents of publishing houses, and warns universities not to waste as much time for adapting new forms of publishing as they wasted for the institutional use of print, waiting 130 years after the invention of print to introduce the first formal university publishing house in Oxford. Centrally and professionally maintained content management systems could provide a vast variety of publishing services activities that mainly take place at the level of departments and are frequently lacking in professional know-how, e.g., reviewed online magazines, working paper series, conference proceedings, departmental histories, yearbooks, educational materials (textbooks), etc.

4.2. Preservation of information by archiving

In addition to publishing, archiving is the second aspect of the function of preserving information. Several impacts of ICTs can be observed here as well.

- *Substitution of physical catalogues:* National libraries, large research institutions, and higher education institutions started substituting digitized catalogues for their physical catalogues and were quickly followed by most other institutions that use any form of archive.

- *Digitization of existing materials and resources:* The next step is the digitization of existing materials and resources. An important initiative in this respect is the Journal Storage project JSTOR [W11], that has pioneered in digitizing older issues of scholarly journals in subjects such as history, economics, literature, science, and some fields of engineering.

- *Creation of online archives*: In the World Wide Web, publishing and archiving converge and sometimes even occur simultaneously. The creation of online-archives, e.g., for working paper series or conference proceedings is a good example of this development. Nearly every institute or department of a research university provides its own online archive.

- *Alliances to share and network databases (catalogues, full text):* As soon as they take an electronic form, it becomes (technically) easy to connect catalogues and to share databases. A necessary prerequisite for this is the convertibility or standardization of metadata. “The Dublin Core and Encoded Archival Description (EAD) are examples of metadata formats” (Drake 2000).

- *Alliances to purchase new material:* To match the power of big publishing companies, libraries are starting to build consortia to get better prices than they would as small, individual market participants. This not only lowers prices for libraries, it also reduces paperwork for publishers and makes it possible to deliver value-added services such as supplying library catalogues with electronic meta-data. As Drake (2000) reports, a consortium for all academic libraries in the United Kingdom has already been formed.

- *Limit redundancy:* Since it is a main task of data management to “limit or eliminate redundancy” (Bernbom 1999, p. 79), it is possible that this will lead to a centralization and/or specialization of archives. It is easily imaginable that only one physical place (a web-server) is necessary for one piece of information, e.g., a scientific paper. This could increase cost efficiency and free resources, but it might also make archives more vulnerable. (It only took a single individual to burn down the library of ancient Alexandria, the central and most outstanding knowledge base of that time.)

- *Changing role of librarians:* Librarians have become increasingly involved in the storage of internal databases and in the organization of access to external electronic databases (e.g., licensing access to online journals). They have become both managers for increasingly complex processes of purchasing, publishing, and archiving, as well as trainers for faculty and students in the use of databases. Their work will become part of more collaborative production processes in their home institutions and in interaction with their environment.

5. Transmission of information: The impact of ICTs on education

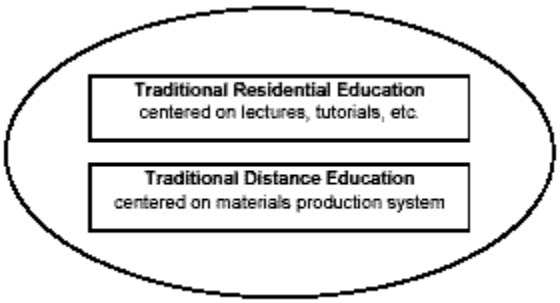
Historically speaking, education might be the last, but, with respect to the resulting impact, it is for sure not the least of the key elements of scholarly activity affected by the cultural changes brought about by ICTs.

- *Student services and student administration:* Normally, universities start to support physical forms of communication by providing additional online information. They begin with distinct tasks such as presenting themselves on a homepage or putting searchable course catalogues online. These features are eventually integrated with one another and supplemented with many other features such as online student registration, assignments, quizzes and certification, course evaluation, etc. Increasingly, university portals are seen as strategic instruments to design the

university's communication with their environment (Olsen 2002), which makes it necessary to enhance coordination within the organization. One side effect is the awareness that the educational experience at a university is determined by more aspects than mere student/teacher interaction. Another side effect is enhanced institutional responsiveness, e.g., in the form of a closer link between internal activity and external presentation. This can be observed in the Urban Universities Portfolio Project [W12], which tries to link internal reporting systems with presentations for external assessment.

- *From product to process:* While residential and distance education have been traditionally regarded as two distinct types of education, the introduction of ICTs emphasizes the fact that each of the two types emphasizes different aspects of education. According to Trevitt (2000), traditional residential education is centered on lectures and tutorials, while traditional distance education is centered on a materials production system. This distinction specifies the functional difference between residential and distance education. Distance education is not just a minor form of provision, as traditional universities would like to believe, but has its strength in the production system for course material. This is a strength most residential universities will have to learn from, while distance providers will have to find more interactive ways to educate. Terms such as "flexible learning" (Trevitt) or "flexible delivery" (Green and Lamb 2000) reflect this necessity to integrate aspects of both traditions for the successful use of ICTs in higher education. It comes as no surprise, that "dual mode" universities (Calvert 2001), which are experienced in providing both residential and distance education, seem to have a certain competitive advantage and are able to take a lead in using ICTs for higher education.

  Figure 1: Flexible Learning



  Adapted from Trevitt (2000)

  Maybe a more precise way to conceptualize this problem is to differentiate between the process of learning and the products (materials) used for this process. In doing so, it becomes clear that in principle, the one does not come without the other. But with respect to the introduction of e-learning methods into higher education, the emphasis of work in a given institution can shift from product orientation, which focuses on the development of learning resources, to process orientation, which deals with course planning and learning progress (Calvert 2001, p. 16). Johnston and Watson make a similar observation. They suggest an even more detailed sequence in the progressive development of ICT-based pedagogical models.

Figure 2: Development of web-based pedagogy

Content centric	Portal centric	Module centric	Performance centric	Learner centric
Content repositories	Road maps to courses and programs	Road maps to bite sized learning	Assessment and accreditation	Dynamic customization

Adapted from Johnston (2002)

This model works well to conceptualize variations of human/machine-interaction, but it does not sufficiently comprise web-based forms of human/human-interaction, such as pedagogical models of teamwork, e.g., problem-based learning or project education that can be supported by groupware or learning management systems.

- *The trade-off between richness and reach:* Using Evans's and Wurster's suggestion (2000), Weigel draws the distinction between richness and reach in the following way: "Richness refers to the overall quality of information (for example, currency, accuracy, interactivity, relevance), and reach refers to the number of people involved in the exchange of information" (Weigel 2000, p. 13). In blurring this distinction, higher education institutions may become confused in their strategic focus. The assumption that the use of ICTs necessarily means (at least partially) adopting distance education (e.g., as a business model to reduce costs and increase enrolment) may result in an unclear vision of whom and how many to address, as well as in unwittingly joining markets that focus solely on price competition. This also neglects the potential of ICTs to enhance the richness and quality of the educational experience. At least for traditional, research-based providers of higher education, Weigel therefore suggests using the term "e-learning" instead of "distance education" to avoid any misconceptions in strategic debates. Additionally, he strongly recommends focusing on the imperative of richness in the curriculum and on the enhancement of academic excellence.

- *From faculty-centered to student-centered:* A qualitative change, which has strong potential to enhance the richness of the learning experience, leads to a new relationship between students and faculty, which frequently is described as a paradigm shift from a more linear to a more circular, feedback-driven form of interaction. Taylor & Eustis (1999, pp. 56-57) make the point that the Internet provides the opportunity for "on-demand learning through access to a remote resource at the student's convenience". In their opinion, this does not only imply a shift from synchronous to more asynchronous forms of learning, but, more importantly, it opens the opportunity to shift the focus from "faculty-centered" (Twigg 1994) forms of delivery to more student-centered forms of delivery. This not only applies to the level of the single course, but also to the level of the entire curriculum that can be customized to the needs of the single individual. The IUPUI Electronic Student Portfolio [W13], a tool for documenting improvement and achievement in student learning, serves as an example of this.

- *Internal collaborations:* Many industries that previously structured production processes sequentially in long chains of fragmented, separately performed tasks, have come under pressure to reengineer this structure in a more concurrent way,

e.g., by building interdisciplinary project teams, composed of members of diverse departments, to work jointly on more complex tasks, such as on a new product. Delhoofen (2001) compares this pattern of change to similar phenomena in higher education institutions. Here also, he observes a traditionally fragmented structure, e.g., of academic disciplines or of highly autonomous teachers, and a trend towards rotating this structure and reorganizing it around more complex tasks. Since the efficient use of ICTs in higher education is an extremely complex task, integrative cooperation across the boundaries of distinct departments becomes more necessary than ever before. "The introduction of online facilities into teaching and learning environments requires the filling of multiple roles (e.g., course planning and design, learning facilitation, managing learning environments and teams, managing the development and use of resources, working with clients and collaborators, advising students, managing assessment, and monitoring and evaluation. … It is neither efficient nor supportive of effective learning to assume that all the roles are filled by a single entity or individual, the teacher" (Calvert 2001, pp. 16-17). This increasing need to link the work of individuals with the goals of the organization leads to major changes in the nature of academic work and the roles of individuals. To design these changes carefully, modern universities will have to find a balance between exaggerated forms of managerialism and the "wishful thinking to expect that some invisible hand will guide the path of individual academics into a strategic direction" (Coaldrake and Stedman 1999, p. 13). A more academically driven example of stronger internal collaboration might be the Technology Across the Curriculum [W14] initiative at George Mason University. The goal of this initiative is to incorporate the training of 10 basic IT-skills into regular courses of liberal arts programs as a way to increase computer literacy and to provide graduates with a comprehensive portfolio of marketable technology skills. A more administratively driven example might be the Learn TechNet [W15] at the University of Basel. LearnTechNet is a cooperation of different support units coordinating and bundling their services to support academics and students, aiming at a modernization and improvement of the learning experience at a residential university with the help of ICTs.

- *External collaborations:* The stunning variety of external, inter-institutional collaborations starts with comparatively simple applications such as joint online-catalogues (e.g., Deutscher Bildungsserver [W16] provides searchable online information on existing programs). A bit more advanced are online communities for exchanging and reviewing web-based course materials (e.g., MERLOT [W17]). More complex is, on a small scale, the development of joint study programs (e.g., WINFOLine [W18] is a cooperation of four German universities to jointly provide an online master's program), or, on a larger scale, the development of courses under a joint didactical concept (e.g., Western Governors University [W19]). On the level of state systems, one can find specialized initiatives focusing on single functions (e.g., SUNY Learning Network [W20], state-wide coordination of support and infrastructure for web-based instruction), or national portals providing online services for all key functions of their traditional research universities (e.g., Finnish Virtual University [W21]). Universities also form huge international consortia to package and globally distribute their education services (e.g., Universitas 21 [W22]). Many new activities in higher education involve private companies, either in collaboration with or in competition with public institutions, sometimes even both. Here again, the less complex initiatives start on the basis of online catalogues and act as brokers for already existing courses (e.g., Mindedge [W23]). Higher education institutions become important customers for software developers, which offer highly specialized

solutions such as learning management systems (e.g., Blackboard [24], WebCT [25]) or integrated campus solutions (e.g., Campus Pipeline [W26]). In the beginning, some companies offered trial versions of their software for free, using universities as developers and testing sites, and are now starting to charge licensing fees. Even more complex is the bundle of technical, organizational, and didactical products and services provided by companies such as eCollege [W27], which incorporates educational software, academic content, staff training, consultancy in instructional design and course development, sometimes even the re-engineering of the entire higher education institution. Costs and the complexity of their relationship to service providers let many universities therefore face "make-or-buy" decisions, considering which parts of their tasks and support structures might be outsourced efficiently, and which parts have to remain under direct control of the university. But cost efficiency is only one side of the coin; fund raising is the other. Goldstein (2000, p. 27) made the point that "technology-mediated learning forces different economic models." While residential education previously acted in a "zero-sum world" of more or less steady markets, successful participation in a web-based distance education market in his opinion requires "significant capital expenses" to create courseware, to keep up with technological changes and to invest in the conquest of yet unknown markets. This is the main reason for many new institutional models, such as ventures between public institutions and private companies (e.g., in 1999 the National Technological University [W28] created a for-profit clone, the National Technological University Corporation, which attracted $15 million in venture capital).

- *Alternative Providers:* Ventures such as those described above can be regarded as some kind of hybrid form of traditional higher education institution, maybe even as an alternative provider. Another form of alternative provider can be seen in corporate universities, which start with online training for their own staff and sometimes see the opportunity also to sell these courses to non-employees (e.g., Motorola University [W29]). In a similar, but different way, the Barnes & Noble University [W30] created a new type of service product in addition to, maybe even as a business driver for, the core business of selling books. Although both organizations do not provide accredited courses or programs and therefore are not direct competitors for traditional universities, nonetheless, they "have much to offer the traditional education sector in the professionalism with which they approach their teaching and learning programs, and the funds expended on these activities" (Cunningham, et al. 2000, p. 15). Another, more serious class of competitors can be found in virtual, for-profit universities, that offer completely accredited study programs via the Internet (e.g. University of Phoenix Online [W31], that focuses on adult higher education).

6. The organizational rationale of the research university

Noam's categories have been very helpful for organizing our observations and for finding examples for the use of ICTs in all of the key areas of the research university. But what does this mean for the university as an organization? Will the university face as dim a future as Noam says? To answer this question, it is necessary first to take a closer look at his arguments about the threats he sees for traditional institutions of research, learning, and teaching.

With respect to research, Noam observes an exponential growth of most scientific disciplines, accompanied by an inevitable trend toward specialization. Both

developments, which are not caused, but accelerated by ICTs, lead to an increased interaction among the remote members of a disciplinary community. His main concern is that this trend might weaken the ties among local peers at the cost of the organization. “Ironically, it is the university that pays for the network connectivity which helps their resident scholars to shift the focus of their attention to the outside…” (1999, p. 4). While Noam’s basic observations may be correct, it is possible to come to different conclusions. At least since the emergence of the modern system of scientific disciplines in the eighteenth and nineteenth centuries, both specialization and interaction with the relevant scientific communities have been prerequisites for innovation and the creation of new scientific knowledge (Stichweh 1984, p. 67 ff.). Therefore, it is no irony, but a crucial necessity for the university to cleverly invest in the connectivity of its resident scholars.

With respect to the preservation of information, Noam observes a trend at universities to “gradually shift from physical presence of information to electronic access. This will in time transform the system of academic publishing and publishers towards one of deposit of articles by authors at various specialized and interconnected sites” (1999, p. 5). Whether one agrees with this observation or not, the question still remains whether this transformation must necessarily weaken the traditional university. Noam sees an economic advantage in the sharing of hard copies of books in traditional libraries, since the costs for their acquisition are lower than the costs for their use. What he does not see is the fact that the same economic principle applies to commercial on-line services: for individual scholars, it is still cheaper to obtain access mediated by their university library than to access directly (e.g. ScienceDirect [W32] currently charges $30 for the download of a single scientific article.)

Noam sees another aspect of the described transformation in the need for arrangements “to structure the flow of information, which requires an organizational structure outside the traditional university” (1999, p. 5). Again, Noam may be generally right, but those structures do not necessarily endanger the institution. They can also serve the university as a complementary part of its institutional environment, as the following example explains: Stichweh (1984, p. 394 ff.) described the scientific journal as an organizational structure outside the university, which uses the university as its institutional background without competing with it. The scientific journal organizes highly specialized communication (among scholars, who are mainly located at universities) alongside disciplinary interests and provides sound quality control via peer review (mainly performed by university scholars).

Any university education that continues to be based exclusively on traditional classroom teaching will come under pressure and could possibly be “provided at dramatically lower costs”, if “alternative instructional technologies and credential systems can be devised” (1999, p. 5). But it is difficult to agree with his conclusion that universities are doomed to be defeated by commercial firms, especially when he suggests that publishing companies are the first candidates for becoming the ultimate higher education providers in this future development. It might be true, that publishers are more experienced with the technical aspects of media production, but in the past this was also true for the production of books. Why did publishing companies not already provide credits on the basis of textbooks? Because education is not a commodity (like books or course materials) that can be delivered uni-directionally, but a service that has to be transmitted

via the cooperation of the receiver. At least in its ultimate realization, higher education at a research university takes place as participation of the student in the research process (Stichweh 1984, p. 86).

Noam is correct in raising concerns about the economic future of universities. It is very plausible that many universities are under pressure to keep pace by raising their productivity with the help of ICTs, which might lead to an increase in economic diversity among institutions of higher education. Less convincing is his concept of the university as an organization. Even if he starts with the most useful distinction of three dynamic functions (production, preservation, and transmission of information) as the key elements of scholarly activity, he suggests an inappropriately static organizational model of the university as a storage of physical entities (scholars, books, students) and therefore ends up with incorrect criteria for the assessment of the university (locality of co-operation, proximity of information, delivery of content).

Contrasting that, Stichweh (1984, p. 83 ff.) suggests a model that is more in line with a functional concept of the university. Guided by the question of why it might be necessary to combine research and education in a specialized type of organization, he came to the following conclusions:

- The system of formal education in western societies uses scientific truth (instead of, e.g., professional authority or religious belief) as its communicative medium. Higher education at research universities is the ultimate level in this system of formal education, the form to which all other educational levels refer.
- Science has a structural deficit of legitimacy towards society. One way to compensate for this deficit is by linking research with education. The ultimate form of linkage takes place in higher education, by including students in the process of research, instead of merely confronting them with the outcome of research.
- The organizational link with education provides a broader recruitment basis for science, compared to non-university research institutions.
- Temporary inclusion of student classes leads to a continuing exchange of people and increases possibilities for innovation.

In other words, universities work well when they successfully organize the integration of research and education in a way that is productive in both directions. Given this perspective, it is easy to see that it is the form of the university that shapes the composition of scholarly activities, and not the other way around. The creation, preservation, and transmission of information are functions of the university as an organization, rather than of the scholar as an individual.

7. Raising the right questions

As seen above, an activity-based perspective requires an appropriate concept of the university as an organization. Therefore, Noam's elements of scholarly activity should be seen as complex functions of the entire university towards society. Now it is necessary to test whether this activity-based, organizational perspective is helpful for raising practical questions to assess the use of ICTs at universities.

7.1. Research attractiveness

Regarding the research function of the university as the task to create new information, it is necessary for the university to enable scientific innovation and to foster scientific interaction. The introduction of individual PCs, email, and the Internet enormously increased connectivity and interaction among scholars, both remote as well as local. In addition to this basic equipment, an institution must further ask:

- Do ICT services at the university provide an environment that is attractive for researchers?
- Does the ICT infrastructure allow efficient participation in research collaborations and contribution to the scientific community?
- Do the electronic assets of the university (information systems, archives, web-portals, etc.) attract the attention of potential partners?

7.2. ICTs in various disciplines

Since scientific innovation mainly takes place at the level of the discipline, and not (significantly) at the level of the institution, it is necessary to acknowledge differences between the academic disciplines regarding their forms of ICT use and their respective requirements in terms of infrastructure and support. In order to take these differences into account, it is necessary to raise some general questions:

- Are there experts in the faculty dealing with academic issues of ICT in their discipline? Does the university plan to set up academic departments for these fields? (While chairs and departments for business informatics are common phenomena, similar structures are comparatively scarce in the arts and humanities.)
- Are there programs in place to set priorities and to stimulate discipline-oriented research on ICTs? (Higher Education in the Digital Age [W33] might serve as an example for such a program in the field of higher education research.)
- What are the typical electronic materials/documents (text, pictures, videos, simulations, datasets, etc.) that are produced in a respective discipline or academic department? Are there institutionalized forms to permanently collect and organize scholarly materials (data banks, archives), or are these documents stored individually? Is their use restricted locally, or can they be made available to the research community at large?

7.3. Publishing

As suggested earlier, the preservation of information can be divided into two aspects: the publication of information and the organization/maintenance of accessibility. A special characteristic of the scientific publication system is that the distinction between the author and the reader is less asymmetric than in other contexts. In principle, every reader of a scientific text is a potential author and quite likely to publish herself. Since the system of scientific publication is gradually shifting from physical to electronic forms of publication, a clear effect is that the work flow from document production to its publication and storage becomes shorter and more integrated.

- Does the university have a policy for intellectual property issues regarding ICTs? (See, for example, a respective framework document of the Association of American Universities 1999).
- Does the university offer guidelines on how to retain the right to self-archive free online versions of articles that have been published elsewhere?
- Does the university offer logistical support (e.g., from the library, for bibliographic issues) to individuals or to departments for creating searchable online archives for electronic papers and documents?

7.4. Maintaining accessibility

It is easy to argue, that the function of traditional libraries was never simply the mere storage of material, even if there might have been some problems with lack of space. The main purpose was to organize existing content, to maintain its availability and to moderate access. Basically, these aspects are still the same. But they are becoming more differentiated and the ways of carrying them out are changing radically. To raise the productivity of a library means to increase the amount of content available, to increase customization in its organization, and to raise selectivity of access opportunities.

- Does the university have a strategy for a hybrid library, blending the use of current physical stock with access to electronic resources?
- Does the university have a strategy towards commercial publishers and information system providers, in terms of cost control and maximizing access opportunities?
- Is there anyone in the organization responsible for screening free online sources and making them available for the appropriate organizational unit (department, school, etc.)?
- Does the university customize information and access opportunities to different user groups, maybe even to individuals?

7.5. Linking research and education

Interpreting the function of education as the task of transmitting information to others, a crucial aspect of higher education at traditional universities, is to link research and education by involving students in the research process.

- Is there electronic material already available from research activities of the various academic departments that can be re-used in a study program, or do course materials have to be developed from scratch?
- What do the practices of ICT use look like in specific disciplines, and what is the best way to introduce these practices into the curriculum?
- Does the university regard the products of its students (for example, theses, dissertations, etc.) as valuable academic contributions, e.g., by collecting them in free online archives?

Harley (1999) describes the U.C. Berkeley's Humanities and Technology Project [W34] as an initiative that circumvents all three of these aspects; it was a discipline-specific project, which involves students in scholarly production by actively stimulating graduate students in their experimentation, and it acknowledges their products by using them in teaching and research.

7.6. The learning university

Traditionally, higher education has addressed a local student population in a restricted market. Therefore, it was (and still is) reasonable for most research universities to start their e-learning activities with a focus on their local environment. Collis and Wende (2002) observe as a frequent pattern that the respective development takes place in three consecutive steps: First is the institution-wide ICT implementation, followed by a stage of rich pedagogical use of this infrastructure, and in most cases, the strategic use of ICT for addressing new target groups comes last.

- Are the various e-learning activities of the university systematically supervised as a way for the institution to learn by experiment? Are experiences and content collected on an institutional level?
- Do the various e-learning activities aim at enriching the learning experience or at cost reduction?
- In a given local market, does the university want to increase enrollment or to shift towards new target groups?

7.7. Different products, different markets

A commonly cited characteristic of ICTs is their potential to exceed the boundaries of restricted, local markets. But it is crucial for the university to clarify exactly what is to be exported. Is it material (e.g., course ware) or services (e.g., a course)? This question seems linked with the distinction between meritocratic and economic dissemination models. Both MIT's OpenCourseWare [W10] initiative and the MERLOT [W19] project transfer free course material and work under meritocratic conditions, since scholarly reputation is the currency on which they are based. This aspect is especially obvious in the last example, where course material is reviewed according to the criteria of communities of specific disciplines. It can be seen as an attempt to establish electronic courseware as an entirely new medium for scholarly publication, comparable to the reviewed article in scientific journals. In contrast, University of Phoenix Online [W31] or Universitas 21 [W22] are ventures based on economic models; they transfer services to generate revenues. It will be interesting to see the ways in which both the meritocratic as well as the economic transfer model develop in coming years.

- Does the university plan to export material or services?
- Does the university focus on a specific local market, or does it aim at a specific segment of a global market?
- If the university exports material, what is the best way to generate attention and reputation?
- If the university exports services, what is the business concept for generating revenues?
- Does the university take a single actor approach in its exporting efforts, or does it join forces, e.g., with other universities in a consortium?
- Does the university have a policy for dealing with imported material or services?

8. Summary and conclusions

This paper began with the assumptions that ICTs affect research universities in more aspects than merely their educational function and that a more holistic picture of the university might lead to a better understanding of the impact and the potential use of ICTs at universities. Noam's distinction of creation, preservation, and transmission of information helps to differentiate and organize a wide variety of the predicted applications.

His approach to re-defining the elements of scholarly activities as different forms for dealing with information has proven to be additionally fruitful as it also offers a pathway for analyzing convergences among them, convergences that might be addressed with the help of ICTs. This becomes especially clear when Noam identifies the preservation of information as a third key element of scholarly activity. Herewith, he raises the awareness of the "material" basis for interaction in research and education, the required stability of information, which is created by the publication and maintenance of accessibility to scholarly documents.

Furthermore, we discussed the need for an appropriate organizational concept of the university, a concept that helps to explain, why and how the university as an organization integrates diverse functions and social contexts, such as research and education. This discussion showed that ICTs do not necessarily have to lead to the disintegration of universities (which would be the case if functions were merely accumulated, rather than actively integrated).

In the final section, we tested an activity-based organizational perspective by attempting to develop practical questions for the assessment of the uses of ICTs at universities. This turned out to be a useful tool for focusing primarily on the organizational functions of the university, rather than focusing on technology. It was not difficult to find questions addressing the coherence between different activities. Additionally, we found that research and education at universities not only interact with respect to content and activities, but also with respect to dissemination models.

As shown, ICTs carry a high potential for scientific innovation and the increase of scientific communication. The connectivity of scholars worldwide does not make the university, as an organization, obsolete. On the contrary, its organization and its infrastructure (server, portals, support units, etc.) are necessary to get connected and to form the background for the development of more complicated applications. Even if neither all universities nor all disciplines act at the forefront of technological developments, experts in the use of ICTs will be necessary in all disciplines.

With respect to publication, it is obvious that scholarly documents were always principally disseminated to a global community of scholars, even if in some cases this community might have been composed of very few scholars. ICTs do not change this, but they change the production processes of scholarly publication. On the one hand, there is a strong concentration process among commercial publishing companies, accompanied by an enrichment of publishing services (e.g., customized user profiles, bibliographic information, etc.). This is followed by the creation of consortia among universities to bundle the market power of the consumers. Additionally, technical and organizational adaptation processes must occur as a reaction to these developments. On the other hand, there are significant trends towards free publications, which either

bypass or complement commercial publishing, a development which is also heavily based on ICTs. In both cases, publication and the storage of information become more integrated than ever before, which strengthens the connection between both activities. The necessary consequence for the university will therefore be that it not only takes on the role of an institutional consumer in the publishing market, but also the role of an institutional provider, by supporting its scholars in their online publishing activities.

With respect to education, it is a paradox that many authors are concerned with the extreme costs of e-content production, while at the same time others observe that "[o]f the entire value chain of higher education, content is the least valuable part" (Wilson 2001). This is not a contradiction, since the costs of production do not necessarily have to reflect the market value of the product. But it raises attention to the distinction between the educational service and the material used, as well as the difference between the respective dissemination possibilities. It might be the case that e-learning material cannot be sold for profit, maybe not even for reasonable revenues, even if primary production is expensive. This indicates a strong similarity to scholarly publications. One consequence is that it might be cheaper to promote the systematic collection of electronic content from various other sources in the university (research projects, publications, dissertations, etc.) for use in an educational context, rather than to focus solely on the production of learning materials. Another consequence is to look more closely at the way in which material is integrated into courses. Traditionally, scholars have used a variety of material for their lectures and seminars, only some of which they created themselves. Not only would it have been too expensive to write textbooks for each course, but more importantly, the process of higher education at universities is characteristically based on the comparison of ideas (materials) from different authors. If this pattern is still in place, which we do not doubt, course material tends to be mainly composed of segments from different sources, from both within as well as beyond the university. Under these conditions, it makes more sense to share and exchange e-learning materials, than to restrict their use to the producer. For higher education as a service, this comprises the task of cleverly arranging material from various sources, organizing access opportunities, and designing interaction with students in a way that they can (at least in the long run) participate in the research process and contribute to research production.

The future of the university as a physical institution (e.g., a brick-and-mortar-building) may be dim, however, it will be dark as a coal mine if it regards itself as a mere warehouse for scholars, books, and students. Instead, more than ever, the need arises for the university to act as an organization that dynamically manages the integration of research, education, and access to information. Therefore, following the rationale of the key functions of the university and using ICTs to support the respective production processes is a necessity. Otherwise, universities might become lost in the wide variety of options.

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