E-teaching - Eroding the Stronghold of Teachers

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Abstract

Internet and the World Wide Web have probably caused the most dramatic paradigm changes in learning and teaching, even more than the printed book. The basic objective of teaching is to transform tacit ('internal') knowledge of an creator into tacit knowledge of another person, in academia usually by a third person - a Teacher. Therefore communication is of key importance in teaching, both synchronous communication between the Teacher and the Student, and - nowadays equally important - accessing and using stored information (libraries and repositories). Especially in the case of stored information their availability, access, and retrieval are heavily dependent on the available communication technology.

In this paper we consider the evolution of communication technology (section 1) from speech, to handwritten and typeset books, to photocopying and fax, to e-mail, to books produced from camera-ready anuscripts, to the World Wide Web with powerful search engines, to ubiquitous computing, and finally to social computing. We discuss how the essential processes of Dissemination, and Teaching (section 2) and the existing Teaching Types (section 3). In section 4 we discuss basic factors of the teaching process together with their dependence on technological progress. this evolution impacts the knowledge acquisition and dissemination by the Teacher especially in relation to the means of the Student for independent access and acquisition of knowledge. Concentrating on academic institutions we identify three groups of factors of the educational process: Time factors, verification/validation factors and impact factors. The new technologies tend to weaken the position of the teachers versus the students with respect to these factors..

We continue by discussing some emerging effects of the introduction of the new technologies (section 5). foremost questions of verification, validation, lead-time of the teacher and surpsing the teacher. We close with a discussion of consequences for the academic institutions.

Keywords: E-teaching; academic education; evolution of communication technology; World Wide Web; lead-time of the Teacher; evolution verification; authentication; quality assurance

1 Communication in Teaching

1.1 Knowledge Transfer and Communication

The basic objective of teaching is to transform tacit ('internal') knowledge of an Originator into tacit knowledge of another person. In our simplified model of knowledge dissemination we use three prototypical roles (fig. 1):

the Originator : The person who created some knowledge which is valuable and is considered to become a part of the scientific knowledge base.

the Teacher : The person who acquires this scientific knowledge in order to pass it along to the Student. It should be noted, that in other circumstances he/she also appear in the role of a Student.

the Student : The person trying to absorb the scientific knowledge available.

Classically (following the SECI-model of [Nonaka-95]) teaching is achieved by first transforming the tacit knowledge into explicit knowledge, which then can be transmitted to another person. Due to division of work and specialization (one of the basic steps towards civilization) the transfer of knowledge is usually taken care of by specialists (the 'Teachers'). Especially in academic institutions (typically universities) the teaching process usually is closely connected to research: for example Austrian universities are by law obliged to perform 'research guided' teaching. This means that Teachers is not only transmitters of knowledge but also Originators. Communication of knowledge is a key in this process (fig. 1). On the other hand the Teacher will not create all the knowledge

by himself/herself: accumulation of knowledge is a generation-long, multi-person undertaking where the Teacher himself also acts as a Student in other situations (fig. 1).
Many Originators themselves have long passed away. In this case the Teacher has to rely on 'second hand' knowledge which has been preserved (and perhaps even distorted).
In the sequel we will analyse the various processes and how they have changed over time and with technology.

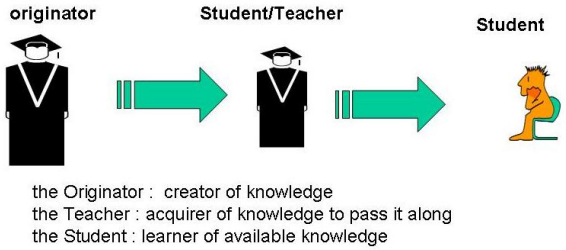

Fig. 1: The basic teaching process

1.2 Relevant Advances in Communication Technologies

Communication is the key to successful knowledge acquisition and dissemination. Historically ICT has provided a multitude of dramatically new communication methods which also impact teaching. Fig. 2 shows key steps of the evolution of communication technology in roughly chronological order. The columns have the following meaning:

technology : major steps of technology achievement. In [Chroust-03b] a lengthy discussion of the individual technologies and their essence appears. Here we have added a new, upcoming one, *social computing*. Today's speed, ease-of-use and ubiquity of the internet makes it feasible and useful to utilize the internet as a basis for community based work. Like in the real world where we ask somebody, we seek and get advice, recommendations and help via the internet, even from total strangers.

new achievement : major new qualities of the new technology. We have selected only those qualities which we believe are relevant for communicating knowledge from one generation to the next [Chroust-98f] [Chroust-99i] [Chroust-99b][Kraut-94], see below for details.

document production and access effort : What is the effort (time/cost) to produce a document? What does it take to gain access to the document?

persistence of document : How persistent is the contents of the document, can it be easily changed, are changes noticeable?

immediate effect : some of the effects on the users (especially in the context of e-teaching) are mentioned.

In column 2 of Fig. 2 we have identified a major achievement of each respective technology:

abstraction : Without abstraction we would never be able to speak about the future, about concepts, about fiction etc. We would be limited to physically observable facts and would have difficulties in communicating them to others, especially over time.

persistence : Only by committing markings to some persistent medium for recording data it has been possible to transport information over time and space [Chiera-68, Doblhofer-90, Noveck-75]. Initially only the persistence in time could be achieved, since the value (and sometimes also volume) of these documents posed economic and/or practical limits to transportability.

volume reproducibility : Printing has allowed, in contrast to hand writing, a practically unlimited production of copies and has thus permitted the sharing of information with many.

Technology	new achievement	document production ("P:") and access effort ("A:")	persistence of document	immediate effect
Speech	**abstraction**	P: n.a. , A:n.a	none	transformation of tacit into explicit knowledge
Handwritten texts	**persistence**	P: usually not very high (depending on material), A: high	depending on material	preservation of original texts
Typeset Printed Books	**volume reproducibility**	P: very high, A: medium (book shop)	very long	ability to disseminate, bringing knowledge to people (push instead of pull)
photocopy/fax	**individual instant reproduceability, fast interchange of text/graphic material**	P: easy, fast, A: (as receiver) very small	high, like paper	transmission and dissemination of individual material without need for a publisher/printer
E-mail	**fast interchange of machine readable material**	P: minimal, A: minimal	very high, when stored	speed of transmission, material can be immediately excerpted and worked on, seamlessness, push technology with respect to communication
books with camera-ready supplied material	**individual production of papers in high quality, cheaper book producdtion**	P: low to medium for book producer (effort carried by submittors) A: book market and electronic offerings	high, when printed, low when on electronic media, unnoticeable changes	reducing the time to publish, reducing cost
World Wide Web / search engines	**cooperation, pull technology**	P: very low, A: very low	very low	ability of find from the computer all which is 'known' in no time. 'pull technology' with respect to communication
Ubiquitous Computing	**immediate availability of access**	P: depends on document, A: makes access easier	n.a.	the advantages of ICT become mobile, can be used anytime, anyplace
Social Computing	**cooperative advice and guidance by peers**	P: like e-mail., A: like email or easier	none, if not stored permanently	being able access the 'whole' community ad libidum , help to filter the enourmous flood of information,

Fig. 2: Communication Paradigms

instant individual reproducibility : Printed books allowed the distribution of knowledge to many. For cost effectiveness rather large quantities had to be produced by a lengthy process. Photocopying (e.g. xerography, nowadays also digital scanning) allows to produce a small amount of copies quickly at a reasonable price and in high quality.

fast interchange of machine readable material : E-mail has permitted the transport of machine readable information over long distances in practically zero time. Moreover the sent document could immediately be processed, modified, augmented etc. This is a property not shared by letters or fax. E-mail pushes the information on the recipient (in the negative case also spam!)

individual production of high quality papers : Desktop Publishing allows the production of aesthetically pleasing documents which have the same appearance as type-set publications. This is also the basis for producing camera-ready books. This reduces the 'Time-to-availability' to a small fraction of time as compared to type setting.

cooperation, pull technology : World Wide Web (WWW) has allowed world wide cooperative exchange of information thanks to powerful search engines. Easy retrieval of facts has become possible. Information is *pulled from* the WWW; potential users do not have to wait until information has been *pushed* towards them.

immediate availability of access : Immediate access to practically *any* information irrespective of location is a supportive technology, making some of the other technologies highly useful. The Library of Congress and all data of the Bureau of Census etc. in their most up-to-date form are available on the mobile phone or on some wearable computer outfit [Hoffnagle-99, Cole-97],

cooperative advice and guidance by peers : It is easy and fast to ask one's peers to get information presumed to be valuable. In their daily life humans have always sought advice from experts or peers. Systems were build to support people in their job performance via so-called Electronic Performance Support Systems (EPSS, [Banerji-95, Chroust-00e, Burgess-00, Racine-04]. Today's system allow to observe user behavior and based on the behavior of peers, these systems advise other users with respect to their actions or decisions ('recommender systems' [Balabanovic-97, Gams-02, Mertens-97, Pu-06, Resnik-97]. Obviously these possibilities offer a Pandora's box!

2 The Knowledge Dissemination Process

2.1 The subprocesses of dissemination

To understand the changes technology has affected for e-Teaching and the position of the Teacher the whole knowledge dissemination process must be considered from its very beginning. Based on [Chroust-05v, Fig. 3] we can describe the process like in fig. 3. The details of fig. 3 will be discussed below.

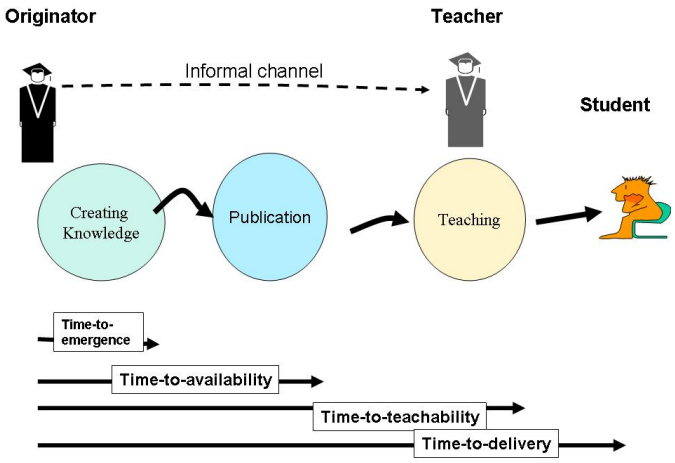

Fig. 3: Basic Delays in Academic Education

We can distinguish the following key activities (subprocesses), some of them have further subprocesses, see fig. 4.

Creating Knowledge : generating new knowledge based on existing knowledge. We can split this process into several complimentary processes:

searching : identifying information, finding it somewhere, collecting it, and actually accessing the contents

authenticating/validating : once a document is identified the question is whether it is a true representation of what it pretends to be. If this is true, then its validity has to be established, to a large extend by comparing with other documentation (which also might have to be searched.

digesting : working with the material, understanding it, prepare it for presentations etc. This may give raise to looking for more (refining) which might lead to another search etc.

filtering : especially for teaching the Student a careful selection of material is needed

presenting : finally the newly created knowledge has to be brought into a form amenable to present to others (book, paper, speech, ..) this might include presentations to a conference.

Publication : in the wider sense, i.e. making it available to a larger public. Traditionally because of the considerable investments (copying, type setting, printing etc.) some evaluation had to take place before actually starting the production. We see two essential subprocesses

authenticating and validating : the proposed text to be disseminated. Publishers want to make sure that the author(s) are not faked and that the material stands up in comparison to other material. To this effect editorial boards, programme committees etc. are institutionalized.

production : of the actual artefact to be distributed,

Teaching : i.e. trying to collect, organize, existing knowledge and preparing it for presentation to the Student The same subprocesses can be distinguished (with minor semantic differences): **searching, authenticating and validating, digesting, filtering, presenting**.

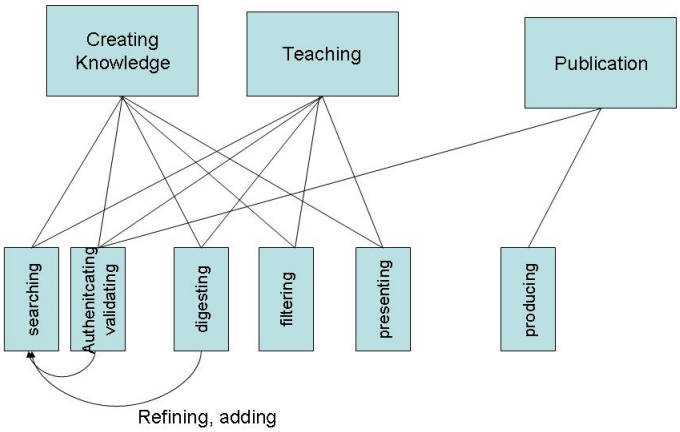

Fig. 4: Subprocesses of Knowledge Generation and Teaching

2.2 The Student's Learning Process

In order to understand the changing relations between Teacher and Student we also have to sketch the essential processes of learning also with the eyes of the Student.

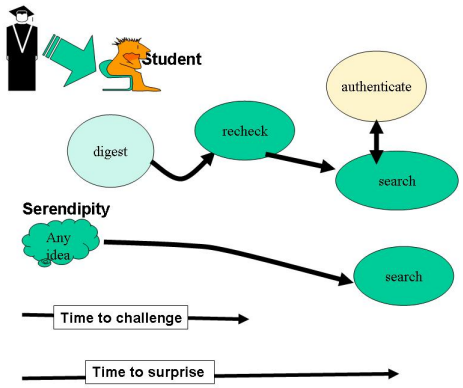

Fig. 5: The Student's Learning Process

The five important processes are discussed below. They differ from section 2.1 only in minor ways.

digesting : receiving the information from the teacher, classically in the form of a

rechecking : During digesting the Student might want to check back whether the citation, explanations etc. were correct, checking the sources used/given by the Teacher In many cases this would additionally cause some searching for additional material ('refining') the presented material, preferable from the original material sources given by the Teacher.

searching : same as in section 2.1

authenticating and validating : same as in section 2.1

Fig. 5 shows a second trigger besides the teaching of a Teacher. A serendipity way of searching available sources for interesting relevant material, often not related to the topic of teaching. Nevertheless this searching might also provide useful material (e.g.unexpectedly finding an old mathematics book from ones grandfather).

3 Basic Types of Teaching Processes

Ignoring some details we can today identify four types of Teaching Environments which emerged in parallel and were supported and enabled by the advances in ICT [Kraut-94]. Technology provided both communication and storage means.

3.1 Speech-based Teaching

Before the invention of writing [Chiera-68] the prototypical teaching process looked as in Fig. 1. The knowledge dissemination process was purely face-to-face. The memory of persons was the only repository for previous knowledge.

3.2 Single-copy based Teaching

The utilization of writing, once it achieved a sufficient ability to express concepts and complex notions [Caubet-01, Chiera-68], brought about a considerable paradigm change [Chroust-98f]: the personal link between Originator and Teacher lost its key importance (Fig. 7). This personal link was paralleled or even replaced by stored documents. This established a certain persistence of the Originator's work. Recording used all kinds of media, clay tablets fig. 6, parchment, paper; etc.

Without a direct link to the Originator, the Teacher has to rely on written material on an intermediate storage medium to acquire the knowledge for presentation to the Student. A body of knowledge accumulated. The libraries and archives of monasteries were key centers of scientific research and documentation. Authenticity could be established even if the Originator was not accessible or dead. The transmission from the Teacher to the Student was and still is largely face-to-face (Fig. 7).

Fig. 6: Mesopotamian Clay Tablet

The access to these usual single copies was obviously difficult and involved effort and even dangers (travel!).

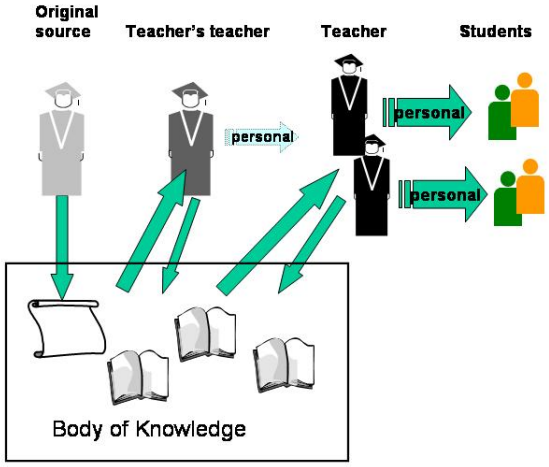

Fig. 7: Flow of dissemination for handwritten books

3.3 Printed-book based Teaching

Printing technology permitted large volume documents and books to be produced in quantities, especially since a large portion of the cost was fixed cost, independent of the number of copies. Off-prints came rather cheap. The value and the size allowed to transport/send books and sell them in different places. At this point the Student could - and eventually did - acquire books themselves, be it by buying or by borrowing from the university libraries (fig. 8). Suddenly there was a real chance to verify the teachings of a Teachings.
Especially with the new combined technology of desk-top publishing and photomechanical reproduction the price for book production dropped and a new type of books appeared: text books, specifically tailored for supporting studying (both for the students and the teachers). Teachers got considerable material pre-fabricated, ready to use. The book industry flourished. In parallel not only books but also scientific journals were growing.
Desk top publishing and assembling books from camera-ready submitted material did not basically change the paradigm, but generated, due to the reduced costs, a flood of new books on the market,especially once the printers were able to directly process material without the detour via printed paper. Especially with printing etc. also another problem arose: more and more researcher wrote *about* the original material, refining it, discussing it, providing "second sources".

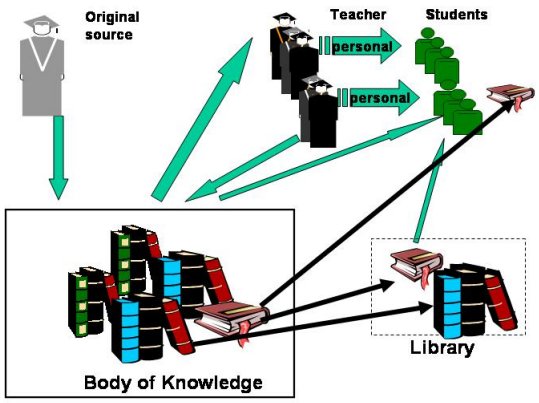

Fig. 8: Flow of dissemination for printed books

3.4 The World Wide Web based Teaching

The World Wide Web has brought about a new phenomenon (fig. 9): everybody can put material on the Web and - due to search engines - also has a good chance that the material is seen/read by a world-wide public. Publication and dissemination are no any more channeled and thus controlled by publishing houses. Looking back into history, in 1517 Martin Luther's way to publish outside the established (church) channels was to nail a document to a church doorof a small village. Mayn of its inhabitants were probably unable to read!
Nowadays the World Wide Web is bidirectional: everybody can read everybody else's posting (at least theoretically). The Web is becoming an enormously large document repository. Memorizing facts looses some of its importance in favor of just-in-time access to the internet.

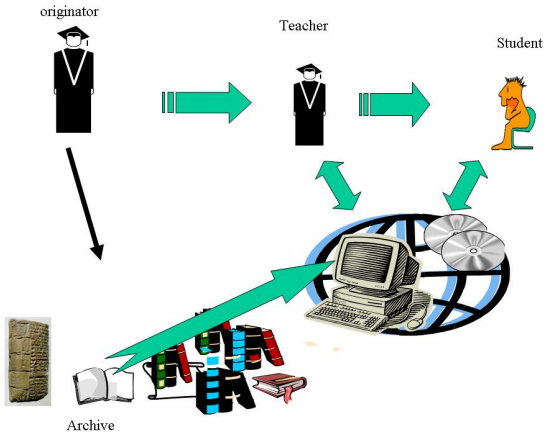

Fig. 9: The influence of the World Wide Web

3.5 The social computing based Teaching

Social computing, utilizing what also is called Web 2.0 [Wikipedia-e, ⇒ Web 2.0], i.e. the technologically supported communication anywhere, anytime, allows users to get quick reactions to questions asked by to other users. The Web binds persons into a network. The Web is able to pro-actively offer services like making personalized suggestions about interesting books or restaurants nearby, so-called 'recommender system' [Balabanovic-97]). Soon this will be also modify the teaching process.

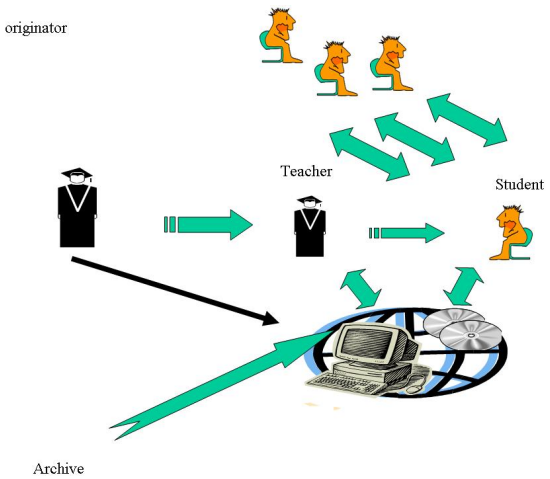

Fig. 10: The Web 2.0 society

A danger is that people will not bother to memorize or learn anything, they will rely more and more on just-in-time advice from just anyone - reliable and knowledgable or not. It seems to be less cumbersome to ask somebody and to get a quick answer than bothering oneself to recherche facts.
The effects and the impacts are not really clear yet. The individuals and the society have still to learn this new medium, to understand the potential and the dangers. To some extent we revert from a reading society to a verbally and iconic oriented 'question asking' society (fig. 10).

4 Essential factors in the Teaching Process

Based on the description of the subprocesses above (section 2.1) and the various technologies we can identify certain key factors and discuss their change due to the different technologies [Chroust-05v]:

Time Factors :

The delays needed for various activities have been dramatically reduces by the new technologies. Especially transmission of information has been reduced to practically zero delay. Some key timings in the teaching process are shown in fig. 3:

Time-to-Emergence : How long does it take from the start of the knowledge creation (vague as this notion is) until the work is finished and ready to be made public?

Time-to-availability : How long does it take until the knowledge is brought into some material form to be made available to a (even limited) public?

Time-to-Teachability : When is the knowledge in a form ready to be taught to the Student (or attendees of a seminar)?

Time-to-Delivery : When is the knowledge eventually actually thought to the students?

Time-to-xx	actor	Single-copy based	printed book based	World-wide Web / email	social computing based
T-to-emergence (T-emerg)	Teacher	very long	very long	long	long
comment			faster production due to better communication (author - reviewers)	faster communication (e-mail), better communication between stakeholders	faster community reaction
T-to-emergence	Student	n.a.	n.a.	n.a.	n.a.
comment		not a student activity	not a student activity	not a student activity	not a student activity
T-to-availability	Teacher	very long	long	same as T-emerg	same as T-emerg
comment		long production	faster production and distribution	reduction due to faster communication of reviewers	still faster due to increased peer-interaction
T-to-availability	Student	∞	long	same as T-emerg	same as T-emerg
		not feasible	long, but can be done via library search	no entry control	no entry control
T-to-delivery	Teacher	long	long	T-emerg	T-emerg
T-to-challenge	Student	∞	long	short	very short
comment		not accessible	cost, ordering	search via internet	even shorter (asking peers)
T-to-surprise	Student	∞	unlikely	faster than teacher!	faster than Teacher!
comment		not accessible	cost, ordering	immediate accessibility	even shorter (asking peers)

Fig. 11: Technology's influence on Timing

Verification/Validation Factors :

Knowledge passed on in a teaching process need not be correct. We distinguish verification (How can one assure that the knowledge one receives is a true replica of what was created?).

The scientific paradigm implies that the process of creation of knowledge is as [Haux-98, p.9] formulates (translated) *a methodical process systematically performed, with inter-subjectively retraceable, goal-oriented research and knowledge creation.*

To consider verification by the Student it is necessary to understand the effort needed to verify the correctness of a claim made by the Teacher. The Student would like to check against the original document as produced by the Originator ("re-tracing"). One has to take into account whether there is a *feasible and realistic* chance to access the original document, considering both the time effort and the financial expenses. Cost and effort depend to a large extend on the applicable technology.

A second issue is *validation*. Validation means checking whether the knowledge is correct, i.e. that is a correct interpretation of facts or compatible with other knowledge. Here the correctness of the offered knowledge has to be compared with and measured against existing *other* knowledge, facts, etc. Key factors supporting verification and validation are:

persistence : Can the knowledge change/be changed without any indication. Will it be in its place in the future?

traceability/verifyability : Having a copy of the knowledge, can one trace it back to its roots? Can one establish that the knowledge was transferred unaltered?. What is the effort to do so?

domain accessibility : How easy is it to find similar, supporting, contradicting material in the domain of discourse, often called the 'Body of Knowledge' [ISO19759-01, PMI-05] e.g. alternate, competing information and paradigms (which often are suppressed or stifled, see [Kuhn-70]).

factor	actor	Single-copy based	printed book based	World-wide Web / email	social computing based
persistence	Teacher	long-lived	longlived,	unsure	unsure
comment		only destroyed by catastrophe (fire, iconoclasts, ...)	multiple copies in official archives (Library of Congress, etc.)	uncontrolled, unorganised	uncontrolled, unorganised
	Student	inaccessible	longlived, archived	vague	vague
traceability/ verifyability	Teacher	difficult	good	fast, but unreliable	fast, but unreliable,
comment			multiple copies available	adresses and/or contents might change without notice	asking 'the community' might help but is unreliable
traceability/ verifyability	Student	impossible	possible	fast, but unreliable	fast, but unreliable,
comment					less inhibition against asking 'stupid questions'
validation	Teacher	very difficult	easy (book shops and libraries)	very easy and fast	very easy and fast
comment			control of publication by powerful institutions (church!), lobbyists	trash recognition difficult	
validation	Student	impossible	easy (book shops and libraries),	very easy and fast,	very easy and fast
comment			control of publication by powerful institutions (church!) or lobbyist, or teacher,	danger of flooding with trash , trash recognition difficult	danger of flooding with trash trash recognition difficult
alternate paradigm knowledge	Teacher	very difficult	difficult	very easy, but flooding	very easy, but flooding
comment			control of publication by powerful institutions (church!) or lobbyists		
alternate paradigm knowledge	Student	impossible	difficult	very easy, but flooding	very easy, but flooding

Fig. 12: Technology's influence on Verification and Validation

Impact Factors : How many Students can a Teacher reach with his/her knowledge. What is the area which can be reached by a Teacher to collect material and existing knowledge?

aura of the Teacher : The *aura* [Chroust-03a] can be understood as the *"totality of all influences and effects around a person"* [Kotzian-98] or the *"subspace which limits the effective presence of an object in a given medium"* [Gross-97, p.98ff]. How many addressees can be reached? How far is the influence of the Teacher felt?

source domain : How large is the area/domain from which information and knowledge can meaningful be consumed. This is, so to speak, the counterpart to the aura. It is the domain from which a researcher or teacher draws information in order to compare and validate his knowledge.

factor	actor	Single-copy based	printed book based	World-wide Web / email	social computing based
aura	Teacher	small	larger	world wide	world wide
comment					recommender system!
source domain	Teacher	small	larger	world wide	world wide
comment					recommender system!
source domaine	Student	null	larger	world wide	world wide
comment					recommender system!

Fig. 13: Technology's influence on Impact Factors

5 Emergent Effects - eroding the Stronghold of the Teacher

The indicated technology changes have far reaching consequences on society - far more than can be discussed here. We will concentrate on the position of teachers, especially in relation to the students.

5.1 Multiplication of stakeholders

We have to recognize that with World WideWeb the players in this 'dissemination game' got multiplied. New technologies allow a much more details and wider search, but also more researchers are at work. This means that despite of the increased speed of search machines etc. the inspection and analysis of the material needs more effort.

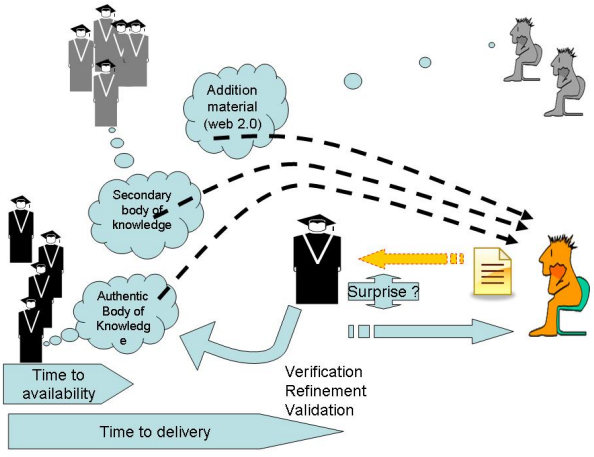

Fig. 14: Overview of e-teaching

5.2 Verification/Validation by Students

As long as a Teacher teaches following a text book (often his own!) there is little danger that the Student will detect major discrepancies - except for typos or slips of the tongue. Looking into other text books did not occur to a larger extent.
Nowadays it is easy to consult the World Wide Web (e.g. Wikipedia [Wikipedia-e]). Thus it is easy to find alternate sources for the same material - often unknown to the teacher - which might give different definitions, interpretations, etc.

5.3 Lost Lead-time of the Teacher

Dissemination of knowledge needs a certain lead-time for the Teacher to fulfil the subprocesses shown in fig. 4. He/she has to acquire information, analyze, comprehend (’digest’) the material, and finally prepare teaching material. Only then the Teacher would be ready to lecture about this subject ("Time-to-Teaching"). In the classical university it will then take some time until the material is actually presented to the Student (waiting for the next term or announcement of a course, etc, giving . the Teacher perhaps some additional breathing time.
Under the classical technologies the Student were unlikely or even incapable of getting the material before the Teacher had presented it. We call this the Teacher’s "lead-time". It is the time the Teacher is able to acquire the knowledge *earlier* than the Student. The lead-time is - so to speak - the safeguard against surprises. The value of lead-time could easily become negative, indicating that the Student is ’faster’ than the Teacher and thus is able to ’surprise’ the Teacher.

5.4 Informal Channels

In a scientific community the key actors usually know one another. This also means, that they know what their colleagues are working at, what knowledge the are just trying to create. Thus even if a Student detects a ’new’ document on the internet, just from the author and/or the title another colleague can make an educated guess what is written in there.
These informal channels are established through conferences, meetings and sometimes by explicit information interchange. The speed up by e-mail/internet has considerably reduced the Time-to-delivery (cf. fig. 3) and thus has reduced the chance for an ’unintended’, informal information exchange.

5.5 Alternative Ideas / Challenging the Teacher

Only with the World Wide Web unorthodox ideas have a good change to be distributed. Being caught in one’s own paradigm (cf. [Kuhn-70]) a Teacher might not realize an idea or ignore it until a Student confronts him/her with it. Chances are good that the Teacher is completely surprised by this.

5.6 No-name papers / Surprising the Teacher

An interesting question is how easily a Student can surprise the Teacher with new knowledge acquired somewhere else?
The Student might by chance (serendipity!) come across some knowledge and present it to the Teacher, perhaps in order to impress or embarrass the Teacher. The concrete document (e.g. a paper or even a book) might be unknown to the Teacher. Usually we expect that the Teacher is aware of his/her field of expertise. How much surprise does the newly shown document hold for him?

6 Summary

The considerations above have considerable consequence on the Teaching paradigm of our days:

Reduced value of stored knowledge : The value of accumulating information will diminish in favor of a just-in-time hunt for the latest information on a given topic [Schneider-96]. This allows to abolish most of the contents of ’shadow copies’ in one’s file cabinet, in the internet one finds these articles faster and more reliably.

Loss of stability and persistence of documentation : We have to live with the fact that the information which we acquire from the Web will be unstable, volatile and often changed. Ways to ensure the permanence and authenticity of results once published have to be designed.

Lost quality control : Currently the Internet has a problem with quality assurance due the possibility of direct, unconstrained publishing. At the same time the filtering mechanism which helped the Teacher to distinguished 'valid' from 'invalid' knowledge via publishers and selected peers (with all the uncertainty connected with validity in science) seems to be lost.

Lost lead time/surprise : Although all previous changes in technology reduced the critical time delays, only with Internet and World Wide Web the Students came into a situation where they could easily overtake the Teacher with respect to acquisition of new information (perhaps even knowledge) depriving the Teacher of his lead-time. The Student presenting to the Teacher a text freshly loaded down from the Internet might surprise the Teacher.

Improving verification/validation need : New verification and quality assurance is needed. Verification and quality assurance (previously done by publishers and programme committees) must be (re-)introduced in an appropriate way in order to eliminate the uncertainty for pseudo-knowledge on the Internet.

Student emancipation : The university system will have to change [Chroust-98f] [Chroust-99b] by helping the student to do more research on their own and helping them to distinguish the quality of documents found on the Internet ("trash-filter").

Changed role of the Teacher : The role and the self-understanding of the Teacher will change. He/she cannot anymore rely on a large lead-time and believe to be immune against outsiders with good ideas. The Teacher will become more an advisor/moderator and interpreter than the owner of knowledge and less of 'lecturers'. And they have to accept the sudden appearance of hitherto unknown information.

Summing up we see that the change in technology (especially World Wide Web) together with ubiquitous computing have caused tremendous changes in the scientific domain. And this strongly affects the relation between students and Teachers, call for a new role understanding of Teachers.

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