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E-teaching - the Lost Lead-time

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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. In this paper we investigate the changes to key time factors occurring in the education process in an academic institution (a university) due to changing paradigms in the information and communication technologies. We identify three important time delays: the *publication delay*, needed to make new knowledge known to a wider public, the *lead-time* of a teacher in relation to the students with respect to new knowledge in a certain field of specialization, and the *source regression delay*, the time to find and analyze an original document in relation to some claims made. We investigate the changes to these time factors from the viewpoint of two key persons: a *teacher* who acquires knowledge in order to pass it on, and a *student* who is interested in this knowledge. We further analyze these time factors from the viewpoint of five key technologies of dissemination and note the resulting changes: oral tradition and dissemination, hand-written books, typeset printed books, books based on camera-ready submission, and the Internet, which receives special attention. Finally some conclusion with respect to academic education and universities are which might balance some of the identified problems.

Keywords: E-teaching, lead-time, academic education, World Wide Web, communication technology

1. THE ACADEMIC TEACHING PROCESS

1.1. The basic process

A student graduating from the Kepler University Linz has to take an oath promising to apply the gained knowledge to the betterment of society. Science has been the driving force for our society and we rely on the work of our predecessors to make progress. Or - as Isaac Newton formulated it - we try *to stand on the shoulders of giants, our predecessors*.

The desire and the ability to disseminate information and knowledge is one of the keys to scientific research [Schneider-96]. Scientific research implies not only the passing of scientific knowledge, it also aims at *"the acquisition of knowledge in a systematic, methodical process with intersubjectively reconstructible and purposeful research* [Haux-98, p. 9].

Academic institutes (typically universities) try to pass the knowledge from generation to the next: a teaching process. This process and the associated education paradigms have undergone considerable change due to information and communication technology [Kraut-94]. Despite the fact that information is immaterial it is necessary to transport it via some appropriate medium. The medium has changed over the past and this implied changes of the way information (especially scientific information and knowledge) is disseminated and the associated time delays.

In the time before the invention of writing [Chiera-68] the prototypical teaching process looked as shown in Fig. 1. This knowledge dissemination process was purely face-to-face.
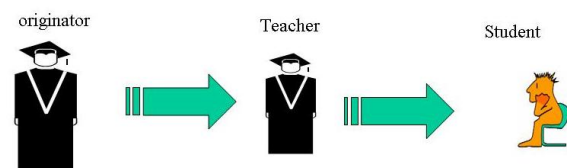

Fig. 1: The basic teaching process

In this simplified model of knowledge dissemination we use only three prototypical participants:

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 students

the Student : The person trying to learn the scientific knowledge available. He/she usually will follow some academic curriculum.

With the invention of writing a considerable paradigm change took place [Chroust-98f], the direct link between Originator and Teacher lost its importance (Fig. 2). At the same time a certain persistence of the Originator's work was achieved by recording it on clay tablets, parchment, paper etc. could be established even if the Originator was not accessible or dead. The personal link between the Originator and the Teacher (in the position of a student to the Originator) was paralleled or even replaced by some stored document. To a smaller instance this also held for the Teacher-Student relation (Fig. 2).
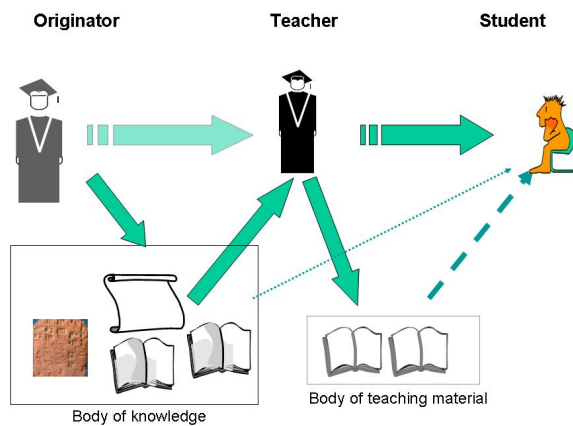

Fig. 2: The teaching process with a knowledge repository

Without a direct link to the Originator, the Teacher had to rely on written material on an intermediate storage medium to acquire the knowledge for the presentation to the Student. A Body of Knowledge accumulated (libraries, archives), especially with the advent of the printed book. Monasteries were one of the centers of scientific research and libraries. The transmission from the Teacher to the Student was and is still today largely face-to-face (Fig. 2). With the growth of the Internet, however, we also see a strong tendency to communicate via e-mail and gradually also to distance learning via asynchronous exchange of material via the Internet [Hirschheim-05].

1.2. Delays in the teaching process

Fig. 3 shows a simplified view of the chain of information transmission from the Originator via the Teacher to the Student. The relevant time delays and important milestones are indicated. They are:

Delay for preparing the manuscript (D_{prep}) : A certain time ist needed (after/during the conceptual, mental work) to produce an appropriate manuscript. Usually some help from a specialist was needed for the preparation, be it a monk writing on parchment, be it a secretary writing the manuscript.

Validation delay (D_{val}) : Knowledge submitted need not to be correct or valid. For scientific books, journals and proceeding of conferences a verification subprocess (performed by editorial boards, programme committees and reviewers) is standard, ensuring a certain quality of the published material. This activity is obvious the cause for considerable delay, especially for books and journals where several iterations between reviewers and the author are not unusual.

Production delay (D_{prod}) : Except for individual (handwritten) manuscripts it takes extra effort to produce a book/journal to be distributed to a wider audience. Typesetting and proofreading takes considerable time. With the advent of desk-top publishing means and the usance to submit camera-ready copies this effort has been drastically reduced. With the printing process the end of production step is reached and the book/journal is ready for the general public to be acquired. The new knowledge becomes accessible to a (sufficiently large) public.

Acquisition delay (D_{acquis}) : In mediaeval times acquisition of knowledge usually meant physically traveling to some often remote place (a monastery) to be allowed to read the manuscript/book there. Very often these books were chained to their support for added security ('chain books'). Scientists interested in printed books/journals have to order it and get it sent to them (causing some mail delay). In the case of Internet it might be possible to load the material down to one's own computer and have it for local immediate availability. For valuable rare books even nowadays it is necessary to request copies by some loan mechanism or even go to their keeping place.

Source-checking delay (D_{srcc}) : Not every document available to the public, even if it is printed, comes from a reliable source which ensures the document has passed some quality assurance process. Detecting (especially on the Internet) some interesting sounding book could still generate some dissatisfaction, if the document is not what it

promised initially. Thus the Teacher has to beware. For well-known publishers or conferences organizer the checking is done in minutes by looking at the names and the credentials of the publisher/organiser. For other sources it might take longer or can even be impossible (especially on the Internet [UMichigan-02]). Especially on the Internet this caution has to include making sure that the document as received is a true representations of the authors opinion and work and not manipulated in an undesirable way. Precautions might imply cross-checking the author's and the source's credentials or even trying to evaluate the actual merits of the document before accepting it as a worthwhile piece of knowledge to pass on. A similar situation arises on software markets with so-called *Software of Unknown Pedigree, "SOUP"* [Hart-03].

Comprehension delay (D_{compr}) : After having the document in one's hand it is often a considerable effort to read it, understand it, draw conclusions and finally prepare the material in a way suitable to be taught to students.

Lecturing delay (D_{deliv}) : Usually there is a certain delay between having the delivery ready and actually delivering the lecture to students.
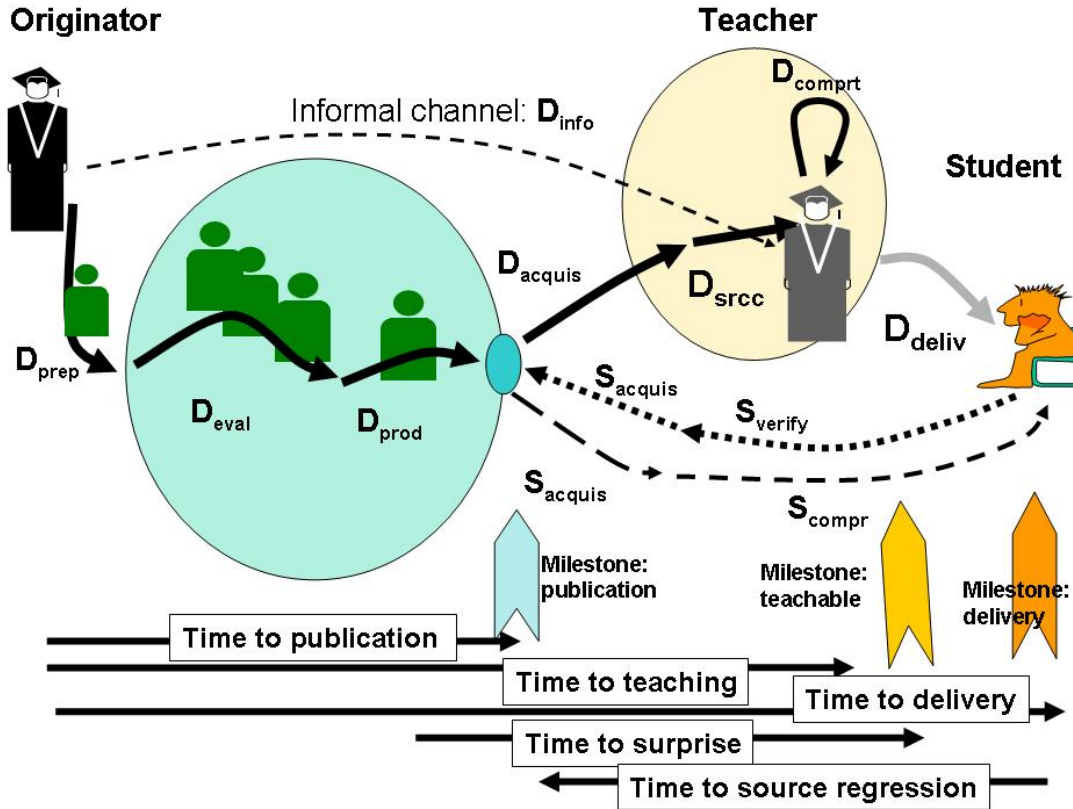

Fig. 3: Delays in the teaching process

1.3. Milestones

In Fig. 3 three important milestones in the teaching process have be marked. The time to reach these milestones can be approximated as follows:

Time to publication (TT_{publ}) : Time to reach the Publication milestone: At this point of time the document is available to the public.

$$TT_{publ} = D_{prep} + D_{eval} + D_{prod}$$

Time to teaching (TT_{teach}) : Time to reach the Teaching milestone: At this point the Teacher is ready to teach the new material. Obviously this time varies with the individual personality of teachers and the circumstances.

$$TT_{teach} = TT_{publ} + D_{acquis} + D_{srcc} + D_{compr}$$

Time to delivery (TT_{deliv}) : Time to reach the Lectured Milestone: At this point the knowledge has been passed to the Student in a lecture or equivalent. This is also the time the Student might want to verify the taught material by checking the original documents.

$$TT_{deliv} = TT_{teach} + D_{deliv}$$

2.   REGRESSION and LEAD-TIME

2.1.   Basic challenges

The time delay until the milestones of section 1.3. are reached are the key to the understanding the impact of changes due to ICT. They have undergone considerable changes due to the various communications technologies and their impact (section 3.2.).

Three important scenarios, in line with the three time factor investigated, will be considered in this paper, all three strongly related to the scientific process in general.

Availability of knowledge : Scientists are waiting for new knowledge and are eager to use it as basis for further research. Reducing the "time to public" is of key interest.

Regression to source (of a document) :   Knowledge passed on in a teaching process need not be correct. Verification is necessary. Therefore it is important 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 ("regression") as produced by the Originator. In this case one has to take into account whether there is a *feasible and realistic* chance to access this document, considering both the time effort and the financial expenses. With the help of the original document one can verify whether the knowledge delivered by the Teacher represents correctly the contents of the original. Cost and effort vary considerably for different IC-technologies.

Lead-time of the Teacher / Surprising the Teacher
This is the amount of time the Teacher is able to acquire the knowledge *earlier* than the Student. 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?

2.2.   Regression to Source

The scientific paradigm implies the connection with past knowledge and implies in principle also the verification of the deduction. There are two delays involved:

Student's Acquisition Time (S_{acquis}) : How long does it take (if it is possible at all!) for the Student to access and acquire the necessary information (knowledge) from an original document. In many instances this will not be possible or feasible (cf. Fig. 5).

Student's verification time (S_{verify}) : This is the time it takes, once the document/information is received to actually verify/falsify that the Teacher's statement was a correct interpretation: the original document could have been written in an unfamiliar language or notation, could be incomplete (old documents), the source itself could be dubious, etc.

The Time to source regression is then given by

$$TT_{regr} = S_{acquis} + S_{verify}$$

2.3.   Lead-time

Dissemination of knowledge needs a certain temporal lead-time for the Teacher (cf. Fig. 3). He/she has to acquire information, analyze, and comprehend ('digest') the material and finally prepare some teaching material. Only then the Teacher would be ready to lecture about this subject ("Milestone: teachable") and some time later will pass the derived knowledge on to the Students ("Milestone delivered"), see TT_{deliv} in section 1.2.

We compare this time span with the situation that the Student finds by mere chance (serendipity) or by purposeful search a document to show to the Teacher.

Accessing a document is not enough, there is a certain understanding needed.

Student's comprehension time (S_{compr}) : This is the time it takes, the Student to understand the found document. Thus in total the Student needs for surprising the Teacher (ignoring a possible search time)

$$TT_{surprise} = S_{acquis} + S_{compr}$$

The lead-time is - so to speak - the safeguard against surprises.

Lead-time (D_{lead}) : When the Student finds a new document and shows it to the Teacher, does it come

as a complete surprise or does the teacher have some 'prewarning', a lead-time? With the new media the lead-time got smaller and smaller, and actually the student could be faster than the teacher.

$$D_{lead} = (S_{acquis} + S_{compr}) - (D_{acquis} + D_{srcc} + D_{compr})$$

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. The possible conditions for a positive lead-time are:

- The Teacher is highly familiar with the document, i.e. (D_{compr} is very small and has a good approximation of the document due to some already received informal channel (making both D_{acquis} and D_{srcc} very small)

- The Student is unable to acquire the document at all (S_{acquis} is ∞)

- The acquired document is so difficult to read/interpret that the Student 'gives up' (S_{compr} is ∞).

2.4.   Informal Lead-Time

The classical knowledge dissemination process as described in Fig. 3 does not take into account informal information flow between scientists. Informal communication at conferences, letters and e-mail exchanges make a scientist well aware of the activities of the colleagues in their own field. Thus the appearance of new paper in essentially the field of this colleague may not cause much of a surprise. Very often he/she might even have pre-publication copies in the hand.

Information delay (D_{info}) : This is the time which it takes before the Teacher receives an early warning (be it by mail, e-mail, by personal contact etc.) get knowledge about this specific new knowledge to become available in the near future. These channels are usually not available to the Student.

Informal lead-time In this case the informal lead-time looks as follows:

$$lead - time^{inf} = (S_{acquis} + S_{compr}) - D_{info}$$

In this case the chance for a surprise *in one's own field of experience* is considerably reduced.

3.   ICT AND ACADEMIC TEACHING

3.1.   Communication Paradigms

In this section we discuss the essential communication paradigms [Kraut-94] and deduce some timing estimates for the delays defined in section 2. and section 3..

Oral tradition : In the oral tradition (Fig. 1) the information was passed on linearly from the Teacher to the Student. No written records existed. No verification by regression was possible once the Originator was dead. Even if the Originator still lived it was often impossible to contact him/her. The lack of original written documentation is typical for most of the existing religions (cf. [Detering-95], [Smith-73]).

Handwritten book : The handwritten books were valuable, expensive to produce and to reproduce. They contained the knowledge of some Originators. On the one hand they were a replacement for the Originator, on the other hand they also allowed verification by regression beyond the inaccessibility of the Originator.

Typeset printed book : The typeset printed book was produced in quantities and made the contents more accessible. The Teacher (or Student) did not have to travel to the source any more, the information could be sent to him/her. The 'state of the art' could now be collected and maintained in many places (libraries, archives). The written text became the yard stick for scientific achievements and evaluation..

Camera-ready based printed book : Software very soon provided sophisticated programs to write, format and edit even fanciful documents. Very soon a growing portion of books is done via text processing tools. Very soon these tools became so powerful and so easy to handle, that the specialists for type-setting etc. were not needed any more. More and more scientists write their articles and books by themselves and deliver the final 'camera-ready' copy to the publisher. Books the contents of which have been produced by text-processing programs have essentially the same properties like the typeset book. The biggest difference is the ease of production (reducing D_{prod}) and thus reducing the time to publication (TT_{publ}). Smaller effects are also the reduction of the preparation time (D_{prep}) due to easier production of intermediate and updated copies. Of high but dubious value is the possibility of 'cut-and-paste', reusing text and figures with practically no effort. This brings a considera-

ble increase in efficiency and reduction in elapsed time.

World Wide Web : The World Wide Web allows 'individual self-promotion'. Anybody is able to put a 'publication' into the Internet, be it a scientist or a ignoramus. The value of production time (D_{publ}) is negligible. The value of the preparation time (D_{prep}) is not explicitly visible or very small - most of the text usually is already prepared when doing the creative work. The text is a by-product of the research produced by text-processing tools (see above).

Putting documents simply on the Web circumvents quality control, reducing total time-to-publication essentially to that part of the preparation time (D_{prep}) which is used to finalize text and figures and format it for web-usage. Since everybody has easy access to this 'published' material the acquisition time (both D_{acquis} and S_{acquis}) also go to zero.

3.2. The Impact of ICT on Delays in formal communication

During the history of mankind communication has experienced considerable changes, some of these changes have had a high impact on the scientific work. They are big steps from a handwritten manuscript stored in a medieval monastery to a book published in type-set form and a publication on the Internet. The delays identified in Fig. 3 and section 1.2. and considering the technological advances (section 3.1.) allow us to summarize the impact of the various delays of the academic teaching process (cf. also [Chroust-98f] and [Chroust-03b]). These changes are indicated in the table in Fig. 4.

Communication Technology	D_{prep}	D_{eval}	D_{prod}	D_{acquis}	D_{srcc}	S_{acquis}	S_{regr}
Speech	null	n/a	n/a	n/a	short	n/feas	n/feas
Handwritten texts	very long	not done?	n/a	very long	easy	n/feas	n/feas
typeset printed book	long	long	long	short	easy	short	easy
camera-ready based books	medium	long	short	short	easy	short	easy
World Wide Web	short - medium	not done	null	null	difficult	null	easy

Fig. 4: Communication Paradigms and Teaching (n/a ... not applicable, n/feas ... not feasible)

Using the considerations in section 3.1. and the values given in Fig. 4 we can give some answers to the relation between the three timing parameters (time to publish - TT_{publ}, regression to originals TT_{regr} and lead time - D_{lead}) as shown in Fig. 5.

Fig. 6 sketches the changes with respect to the verification: One notices that every technological advance improved the verification ability (by regression) of the Student, except Internet. There we experience a considerable fall back. The lead time of the Teacher, on the other hand, continuously dropped potentially falling below zero, meaning that the Student might have an information advantage over the Teacher.

Communication Technology	time to publish TT_{publ}	Source regression D_{regr}	lead time
Speech	n/a	n/feas	extremely long (students usually unable to access Originator)
Handwritten texts	long (access usually only in one specific location, e.g. a monastery)	long (access usually for students prohibited)	∞ (access usually for students prohibited) students usually unable to access original document)
typeset printed books	many months (type setting, proof reading, mailing, printing)	short (publisher's usually comparatively easy to access)	moderately long (informal channels usually available, high price of books)
camera-ready based printed book	short (contents supplied by author)	short (publisher's usually comparatively easy to access, digital libraries make texts accessible	sufficient long (pre-version of books and papers circulate)
World Wide Web	very short (homepage, can be found by search machines)	easy, if URI is known, problem is volatiliy of internet site [Soloway-97]	**negative!** (student can find the text *before* the teacher)

Fig. 5: Communication Paradigms and Teaching

3.3. The Impact of ICT on Delays using informal channels

The problem with the diminishing lead-time is partially buffered by the means the Internet offers, be it by informal notification by the presumptive author or by powerful search mechanisms (the effect of which was not discussed in this paper). E-mail intensified the informal channels and provided a faster information exchange within the scientific community and thus helps teachers by supplying them with pre-publication information.

4. CONSEQUENCES

Improving verification potential : The question of verification via regression could be handled by some electronic equivalent of a Library of Congress.

Lead-time : For the problem of diminishing lead-time no solution seems to exist at the moment. We have to reach a new understanding of the role of the Teacher, with new rules and new ways of looking at teaching situations - hopefully to the betterment of society.

Lost quality control : Currently the Internet has a problem with quality assurance due the possibility of direct, unconstrained publishing

Submitters outside of the established scientific community : Not being bound into a network of peers, outside scientist have a chance to pronounce their ideas but create the problem of surprise to an established Teacher

Changing approaches to academic education : The facts and trends indicated above force us to rethink some of the academic traditions established over centuries. Some changes are/will be:

from collector to hunter : 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], abolishing 'shadow copies' in one's file cabinet.

from teacher to guide : Teachers have to become more of interpreters and less of 'lecturers'. And they have to accept the sudden appearance of hitherto unknown information.

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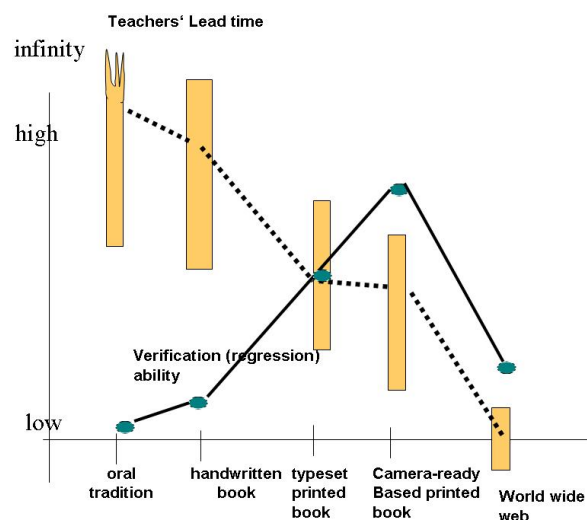

Fig. 6: Lead time and verifiability for various dissemination methods

5. CONCLUSIONS

Although all previous changes in technology reduced the critical time delays, only with Internet and World Wide Web the Students are able to easily overtake the Teacher with respect to acquisition of new information (perhaps even knowledge) depriving the Teacher of his lead-time. 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. The Student presenting to the Teacher a text freshly loaded down from the Internet might surprise the Teacher who might not know it. With the high amount of newcomers on the Internet and the short dissemination delay, there is a good chance that he/she does not know this person. The following necessary steps have to be taken:

- The role and the self-understanding of the Teacher will change. He/she cannot anymore on a large lead-time and believe to be immune against outsiders with good ideas.

- The Teacher will become more an advisor and moderator than the owner of knowledge

- The university system will have to change [Chroust-98f] [Chroust-99b] by helping the students to do more research on their own and helping them to distinguish the quality of documents found on the Internet.

- Verification and quality assurance (previously done by publishers and programme committees) must

be (re-)introduced in a appropriate way in order to take out the uncertainty for pseudo-knowledge on the Internet.

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