Information Technologies and the Training of Teachers

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Teaching and learning in the information society is undergoing radical change. The new challenges make it necessary to rethink the ways of educating teachers so that they can cope with them. We show that teaching has to be considered as skilled practice, consisting of numerous component skills which have to be trained so that future "knowledge workers" can successfully deal with unstable, uncertain and complex situations. As a practical application of this argument, we outline a project for an integrated Internet service.

1. Training teachers

There is growing evidence that we cannot provide students in advance with all the knowledge they would need to solve the problems the information society confronts them with. Increasing complexity of professional work and its rapidly changing environment show that much of the knowledge that students have been taught and keep in store is useless. The main factors that prevent general knowledge from being successfully converted into concrete practice are uncertainty, uniqueness and value conflicts. Some authors even speak of a crisis of confidence in professional knowledge and demand a radical re-thinking and re-design of teaching and learning, e.g. [15], [16].

It is not possible and, in fact, not sensible anymore to provide learners with pre-given answers to pre-defined generalized situations. What they rather need are the skills for investigating themselves the complex, new and uncertain situation they have to deal with. This kind of work is what is usually called "research", or, using a modern term, "knowledge work". Teachers have to get all the necessary skills to train the future knowledge worker, e.g. they have to become researchers too.

Knowledge workers typically have to "consume" and "digest" information from widely varying, dispersed and uncategorized sources. They are being changed by information and seek to change others by it. Changing context is characteristic of the situations knowledge workers have to deal with. Buckingham Shum ([3] p. 902) calls these situations "wicked problems", as they cannot be solved by known methods and pre-defined procedures. The process of identification and definition

(or, as we would say: construction) of the problem is itself the main task at hand, requiring complex judgment and negotiation among the stakeholders. In this process of framing the problem, the goals, constraints and possible solutions change permanently, as does the need for and use made of information.

Research as a professional activity is, in our understanding, not restricted to the research professionals at unviersities and in R&E departments in industry, but rather a basic and essential skill for knowledge workers in the information society.

2. Old problems and new challenges

The need for special training of this capability that we might call, in a first approximation, the "research skill", is reflected by the wealth of textbooks, introductions and guides on the market. Special lectures and courses around the issue of "How to do research work" acknowledge the fact that knowledge of the field is not enough to become a researcher, but that "doing research" implies particular methodological abilities and skills that can be taught and trained separately and, to a certain degree, even independently from the subject area. Despite this abundance of material and despite their efforts to learn from them, many people still get into trouble when they have to apply to practice what they have learned. We believe some reasons for this to lie in msiconceptions about the role and orientation of preparatory training:

a) *Outdated techniques instead of media integration:* Books – and, we are afraid, courses as well – have not yet taken in the far-reaching effects that the information society has on the way research is done. To avoid misunderstandings: Publications like "Guide to Information Access" [18] *do* proliferate and obviously satisfy a certain demand. What is missing in most of them is the connection between the use of the Internet and its impact on the way of working scientifically.

b) *Learning on store instead of on demand*: In many of our curricula, the courses on this subject are placed early, sometimes at the very beginning of the curriculum. Novice researchers cannot make immediate use of the knowledge and just store or forget it. At the time when they really need it, however, they often don't dare to ask again things that they are supposed to (or feel they are supposed to) have known all along.

c) *Factual/procedural knowledge instead of skills*: Courses as well as books on the subject often limit themselves to presenting the formal rules and requirements (e.g. of quoting and referencing a book). But factual knowledge (*knowing that* something is the case) and even procedural knowledge (*knowing how* to do something) are both kinds of *theoretical* knowledge [1]. Although being necessary to help the student acquire the skills for doing research, they are only a prerequisite for the ability itself. To know how to do something is not the same as to be actually able to do it – nobody can learn to drive a car by merely listening to an explanation or watching a skilled driver.

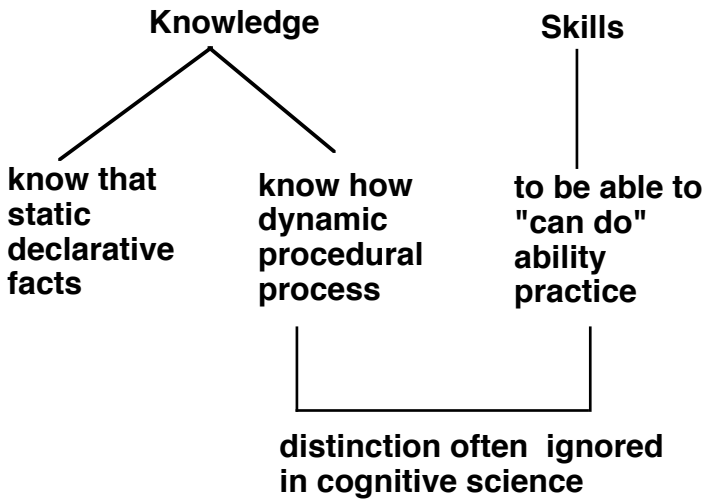


Fig. 1: know-that, know-how and skills

3. Research as skilled practice

Research work is neither an art that cannot be taught or learned, nor a set of rules and regulations to follow. It is a skill, or better a set of skills, that can be acquired (at least to a certain degree) and whose acquisition can be supported by training.

The mastery of a skill is not a question of "all-or-none": it is not the case that one day we are unskilled in a field and the next day we are experts. There certainly are steps and phases in the acquisition of skills, i.e. in the emergence of the capacity. Following the model proposed by Dreyfus and Dreyfus [8], who distinguished five steps in the process of passing from novice to expert, we have outlined elsewhere [2] a three-dimensional heuristic model of teaching and learning.

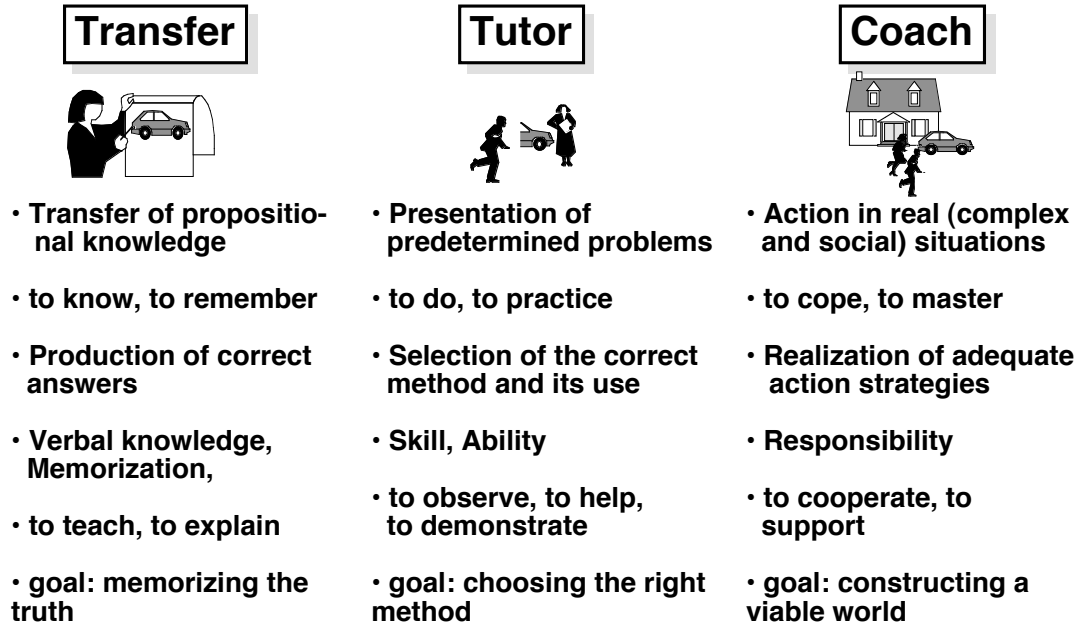
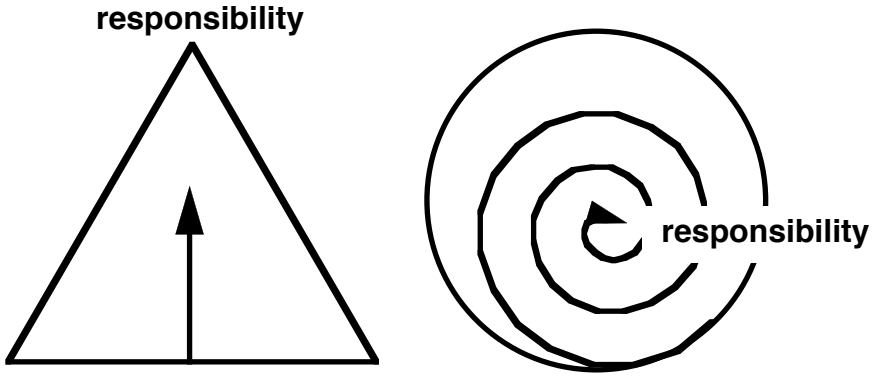


Fig. 2: Models of teaching

The social perspectives and implications of these styles of teaching are substantially different. The knowledge transfer model is based on the belief that there exist people who know the right answer to a pre-defined question (e.g. the teacher). It is heir to a positivist tradition and corresponds to a hierarchical career model with competition at its center. The "situated learning" model, on the contrary, subscribes to the constructivist viewpoint where the coach collaborates with the learner to cope with a complex real situation for which neither of them has a ready solution. At the beginning of their concerted action, learners legitimately participate only peripherally [11]. During the learning process, their responsibility grows continuously until the learners can themselves act as coach for other, new learners.



career model	competitive, hierarchical	collaborative
background	positivist	constructivist
result	true/false	viable
learning	transfer, on store	situated, legitimate peripheral participation
model	"lonely"	"co-operative"

Fig. 3: Career and learning models

4. Research skills revisited

The difference between commonsense knowledge and scientific knowledge is not the quality of knowledge itself. Both types of knowledge are structured experiences that one has to develop, acquire, examine and apply for a viable (successful) action. The quality of knowledge does not depend on the difference in range and object domain [12]. Scientific research develops (or should develop) knowledge in a systematic way and uses a meta-language (second order language) to describe the ongoing procedures and activities [9].

Whatever skill we want to train, we need a second order language which functions as a training language. The lack of a meta-language in scientific thinking is the biggest problem we have to confront in training research skills. The existing meta-language describes mainly the products of research but not the activity, the process itself. In training the knowledge worker, we find ourselves in a position where we can only judge if the product fulfills the scientific standards but not the skills that have to be improved. We are like football trainers who can only comment the outcome of a

game, qualifying a won game as "good" and a lost one as "bad", without being able to specify *what* was good or bad, what should be improved and how this could be done.

A prerequisite for training research is therefore to develop this meta-language, starting with identifying relevant actions and processes that make up the complex practice of doing research. What results from this exercise is in fact a whole list of different skills:

skill	**to be able to ...**	**Tools and techniques**
creativity skill	generate ideas, associate concepts, think freely, play with ideas	mind-mapping tools
conception skill	translate ideas into questions and working hypotheses	outlining tools
planning skills	plan feasible projects	project planning, diagrams, timelines
self-monitoring skill	control and reflect one's own progress	project management tools
methodological skills	choose and follow a method	work flow tools
mining, selection and evaluation skills	find information and resources, assess the quantity and quality of material	search, information retrieval tools, see also 5.1. and 5.2 below
integrating skills	use feedback and input from experts, colleagues and integrate it	communication tools
collaboration skills	work in teams, project groups	collaboration tools
reading skills analytical skills	understand and use resources	browsing, skimming, analytical and comparative reading
logic skills	argue for and against theories and positions [13], [19]	following and building arguments
scientific writing skills	present and document one's arguments follwoing accepted methods and standards	bibliography management tools
language skills	present the research and its results in logical and readable form	writing, composition
publishing skills	bring research into a form fit for publication	electronic publishing
rhetoric skills	present results, questions, arguments etc. publicly	presentation tools and techniques
discourse skills	contribute to and benefit from the discourse in the scientific community	electronic communication, collaboration and co-operation, see 5.3

Table 1: Component research skills

5. Changing knowledge work in a changing society

With computers and especially the networked computer, open to a vast, worldwide and daily growing ocean of data and, at the same time, offering new sets of tools to retrieve, process and transform these data into information and to create knowledge out of this information, the skills of

the research worker undergo radical changes. Research and knowledge work itself, we maintain, change in nature in the information society. We will discuss here some of the challenges that the Internet raises today and the "new skills" that are required to cope with it.

5.1. The need for quantity assessment – selection skills

The most striking factor that comes to mind is the quantity of accessible information. It is not, in the first place, the amount of data itself that has increased with the electronic media. What has changed radically with the Internet is their accessibility. We are still far from the day when all publications are digitized and available electronically in full text, but the rate of electronic publications grows fast, and we may say that if the texts themselves are not yet available in their majority, at least the references to them certainly are. They are accessible in a way they have never been before: virtually from every place in the world, and wherever they are produced, stored and distributed. It has now become possible for everyone to get hold of internal reports or discussion papers of some distant research institution, while not long ago in-depth familiarity with the scientific community or sheer luck would have been the only way to come across such sources.

In theory, it would be possible to get a "complete" overview of a research field. In practice, however, this goal cannot be reached. The sheer amount of available data on almost any subject would exceed the capacity of any student in time, money, and force. There would be hardly any capacity left for processing, understanding, using and, first of all, transforming these data into knowledge and developing new arguments and theories. Whereas the accessibility of resources was a "natural" limitation in the past, there are no such external boundaries anymore. Hence, the student needs the skill to draw the limit herself, by setting up her own criteria and conditions for what constitutes a necessary and sufficient amount of data for the work at hand. This certainly is a new skill that has to be learned.

5.2. The need for quality assessment – evaluation skills

If the selection skill allows "quantity control" of data, there is also "quality control" to be considered. Data are stored in the millions of nodes of the Internet in the same form, i.e. in digital form. All data being uniform and basically equal, there is, at first glance, no outward sign of their reliability, relevance, quality, acceptedness etc. The reviewed article in a renowned journal appears alongside the personal, spontaneous, un-referenced essay of a self-appointed scholar. As a student who is only just getting familiar with her field of research has no means to assess the relative quality of the contents (which might be equal - or why not higher in the informal essay?), she needs criteria to evaluate the usability of the information. This requires skills to put information into context and to assess its quality by certain phenomena of appearance, context, background. In former days, the fact that a book had been bought by the local university's library might have been sufficient to guarantee that it could be used as a resource for research work, and the question of quality arose only later, on the contents level – and at a time when the student was already able to assess the quality of contents. So if the need for quality assessment is not wholly new, it arises at least in completely different form and with much more urgency.

This evaluation skill, as it might be called, would have to include, for example (cf. [14]):

- Checking the reputation of an electronic journal: background research on the authors publishing in a certain e-journal, e.g. by checking his/her homepage and list of other publications, the editors of the journal and the institution that hosts it.
- Footnotes and links: electronically published papers still have to adhere to the principle that scientific work has to be documented. On the Internet, this is partly done by notes, partly (and increasingly, as the part of electronic publications used as research resources grows) by links (URLs) to the source that is quoted. These links have to be verified.
- Date of publication: (Serious) servers and web pages include a "last modified" date. The reader has to be able to evaluate whether the information is still up-to-date, whether the server is well maintained.
- Validation of contents: Students must develop their capacity to judge from the contents whether it is a well-established part of the scientific discourse in the specific subject area, whether it is based on the acknowledged resources and theories in the field.

5.3. Globalization of research – 3C skills

The worldwide networks and the disappearance of geographical distance make research collaboration on a global scale not only possible, but almost unavoidable. Just as there is no excuse anymore for not knowing what is being done in a certain field on the other side of the globe, there is no good reason for doing "stand-alone" research. While science has always been the business of a community and essentially a discourse among schools and theories, the phenomenon of discursive research has acquired a wholly new dimension with the advent of tools and technologies for global communication, cooperation and collaboration (= 3C). While cooperation can be characterized by division of labour, drawing on and bringing together knowledge distributed among the participants, collaboration is the joint work on a subject or product, whereby the group as an entity generates shared knowledge [7]. Communication, then, as the broadest of these concepts, is the necessary, but not sufficient precondition for both kinds of group work, covering every kind of exchange, request, offer etc. of information.

Researchers need to be able to take part in and contribute to the global network, across different languages, cultures and forms of organization. The 3C skills include the choice of the appropriate media and tools for the type of communication, group and task at hand and the successful use of these tools, where "successful use" does not only mean the ability to run the specific tool or application, but also to take into account the limitations and particularities that it imposes on communication and to make up for them through meta-communicative skills.

6. Training research skills with Internet support

While the skills listed above are not new in themselves, the third column of the table demonstrates that they imply a totally different range of techniques and tools then they would have, say, twenty years ago. The logical consequence of this change for learning in context ("situated learning" [4, 10]) is that the support for training these skills itself should make use of the new media that are able to integrate information, interaction and tools.

According to the three main approaches in constructivistic educational theory the training of research skills could be supported in three different ways:

a) *Cognitive Apprenticeship* [6]: We provide different kinds and qualities of guided practice e.g.

- general information and resources permanently updated and verified. These include links to libraries, grants; reviewed software tools (freeware or demo versions) for research work (e.g. mind-mapping software, bibliography packages); sample macros, stylesheets, forms etc.
- training modules for research-relevant Internet techniques (e.g. searching for and in online databases, assessing the quality of resources)
- interactive tele-learning modules with "human backing" for general research skills like research design, writing, argumentation, referencing.

b) *Anchored instruction* [5]: Starting with common authentical problem situations, we could offer a wide range of activities to tackle them:

- FAQ (frequently asked questions) collections
- moderated and guided discussions
- online interconnections among users
- modular tele-learning courses for different authentical problems (how to limit the hits of search engines, how to quote Internet resources, ...)

c) *Cognitive flexibility theory* [17]: Learning to defend different points of view and to take multiple perspectives:

- giving different examples of the same task (e.g. paraphrasing a certain quotation, constructing the same argument on different logical bases ...)
- defending different points of view (e.g. presenting the arguments of an author and of his/her critics, summarizing advantages and disadvantages of a certain procedure, product ...)
- choosing different methods on the same subject (taking a commensense approach and a scientific approach, proposing a pragmatic and a theoretical solution, seeing a problem in short and long term development ...)

Making resources and training offers for research skills permanently available also addresses the need for learning on demand. Skills cannot be acquired on store and in one step, but require permanent training and refinement. With the help of an interactive website, learners could train their research skills whenever they need them and in unison with their growing competence and the increasing complexity of their research tasks.

Summary

Interconnected problems, rapidly changing unstable environments, and an indeterminate future of our society challenge our traditional education system. What is needed is not only factual and procedural knowledge for solving pre-defined problems but the active skill of framing problems, designing desirable changes and inventing ways to bring these changes about.

Research is not a gift based on "talent", "intuition" or "art" but a skilled social practice that can be learned and trained. What we need is a second order language for this training process that satisfies the following criteria:

- definition and isolation of different kinds of research skills and training of these skills
- development of a programme to progressively chunk these different kinds of isolated skills to acquire a gestalt view of the research process
- integration of the challenges raised by new technologies in a self-study socio-technological environment.

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