Science with and without e.

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ABSTRACT

Though the final extent of the change is difficult to estimate, the perception of e-science as a transformation of the everyday professional lives of scientists (scholars, researchers) is common. Besides, there is only little knowledge about the everyday professional life of scientists. Therefore, it is difficult to measure the change, but that would facilitate an understanding. Furthermore, it is important to recognize performed tasks or relevant processes and how they are carried out in order to understand potentials and limitations of e-science. We analyzed everyday professional lives of scientists by a qualitative study with 19 researchers among various disciplines and identified attributes like role, collaboration, and internationalization leading to a usage of tools among the context of e-science. The presented research is developed in the theoretical foundation of Heinrich's Human-Task-Technology framework and enables herewith a guided further exploration of the topic.

CCS Concepts

• Information systems → Information systems applications → Collaborative and social computing systems and tools

Keywords

e-science; Human Task Technology Framework; Expert Interview; Science 2.0; Science; scholarship

1. INTRODUCTION

The *e* as abbreviation has evolved as prefix to a couple of terms in private and professional elements of human life. It encompasses a transformation into online networks and the usage of information technologies in general. It does not only imply the transformation to an electronic transmission, but also the changes to the transformed processes [4]. Science (in its most general meaning comprising all disciplines often referred as scholarship including [1]) has been subject to this transformation, too.

Enhanced science (e-science) means that “[...] the procedures and practices of traditional forms of science in which scholars engage during their everyday professional lives are undergoing radical change”. [6] It “[...] encapsulate[s] the technologies needed to support the collaborative, multidisciplinary research [...] emerging in many fields of science.” [4]

Although the extent of *radical* and the modality of change are discussed, it is beyond dispute that the change takes place during Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the Owner/Author.

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i-KNOW '15, October 21–23, 2015, Graz, Austria
ACM 978-1-4503-3721-2/15/10.

<http://dx.doi.org/10.1145/2809563.2809619>

the professional daily routine of scholars. In order to give prove to it and describe the change, some enquiries aim to quantify the usage of online tools like [13] or [1] according to a variety of aspects or provide case studies that present the application of e-science information technologies to projects [12], [15], [10]. One other study explores everyday professional lives among humanities in order to use the findings for a better organization of processes in libraries. [7]

Concerning the processes taking place in an everyday work life of a scientist a fundamental work has been published by [8]. They present a model dividing the research process into management, core and support processes without any linkage to information technology (IT) and tools.

A holistic perspective on tasks and technologies is missing which establishes a foundation for a detailed analysis. We aim to explore and structure to identify and understand relevant aspects. The presented research contributes to the field of e-science by enabling an identification of patterns of an everyday professional life of scholars and enabling a further assessment of the field by providing a conceptual approach through the application of the Human-Task-Technology-Framework [3].

2. THEORETICAL FOUNDATION, RESEARCH DESIGN AND RESEARCH EXECUTION

2.1 Theoretical foundation and research design

The research method expert interview according to [2] is selected to enable the collection of a lot of information in a short time. Our examination complies with an instantiation of Heinrich's Human/Task/Technology [3] framework: the researcher or scholar corresponds to the human perspective, the task perspective corresponds to the tasks being carried out in everyday professional live of a scholar and the technology perspective represents IT like online tools or grid technology used to fulfil the tasks.

2.2 Research execution

Sample

19 experts agreed to participate in the semi-structured interviews within the phase of data collection between 1st February and 30th April 2015. All relevant kinds of institutions have been covered: universities, universities of applied science and non-university research institutes (according to [3], [18]). The interviews lasted between 25 and 95 minutes.

Analysis

The analysis of the data being gathered basically follows the steps defined by [11], [2]. Additionally, all interviews were entirely transliterated. The coding took place by ordering the transliterated

passages according to their subject. The grouping was cyclical corrected within the increasing amount of evaluated interviews [5].

Teaching: As we mentioned it as example for field of work, teaching was considered by every interviewee. As expected, all non-university research institutes members agreed that teaching is not important for their everyday work life. “teaching is very rarely part of my work _ maybe one or two lectures per year ...”. Among the scientific assistants teaching covers a range from irrelevant up to high relevant. “teaching [added by author] I can say_ that’s zero.” “Of course, there is teaching”. Regarding professors, teaching was the predominant field of work for employees of a university of applied sciences. For 9 out of 11 professors, teaching played a major role.

Administration: The field of work administration was called by almost all interviewees, but within the group of research assistants with a bachelor/master/diploma degree just once. Research assistants with a higher degree announced that field in every case. The interviewees mentioned project management and acquisition as well as networking. One interviewee claimed that “[...] the major part of my work is not related to science or is just distant related to science _ its more administration and such things like human resources management _ in most of all cases in projects as services _ and a further major part is the project acquisition” This was confirmed by the non-university research institutes as well: “... I can only do quite a few things _ instead I have meetings _ we meet every or every second week...” Further tasks among administration are PhD- or technician’s supervisions, the preparation of committees, the organization of workshops or events, the work in administrative positions like dean of a faculty or the supervision of cooperation treaties.

Funding: In regard to the field of funding, the interviewees have opposed opinions. Whereas some interviewees claim that funding dictates research “No_ they [funding added by the author] dictate work.” “We have to do that as we are almost 60 persons_ 10 are financed by the university_ 50 are funded employees_ it is necessary to raise funding! [...] funding is a part of research.” “Funding is relevant for us.” A participant holding a junior professorship explained: “I have a limited position_ and there is no unlimited position in sight_ all I do is just for myself, not for the university as I have to leave in three years_ that depresses me_ It is difficult to be motivated_ especially if the topic does not really suit.” The members of non-university research institutes stated, that “we can concentrate on our research_ we are well staffed”. Contrasting, one university professor admitted: “My experience is_ that the cost/use relation is not right_ the time you have to spent for such a proposal to get funding is over proportional high and the probability to get something is not 100%, it is 50% or 30%_ however_ at the end of the day we decided to neglect to do that.” The mentioned tasks among funding are quite similar to research, besides writing a proposal. “[proposals added by the author] are done with Microsoft Word.” “Google Docs is very often used for proposals.” Only one interviewee, who regarded him/herself as being experienced with international projects and collaboration, stated to use an online project platform named Projectplace. The interviewee motivated that by the necessity to coordinate huge projects.

Research: 18 out of 19 interviewees announced research as an essential field of work. One of the interviewees reported to be happy about having done a sabbatical where he was relieved from administration and teaching and spend some time doing research. Research has a lower priority at universities of applied science than

at universities, as there is a higher teaching load. “on the third place_ there is research_ being more than just praxis oriented research...”. “The rest of the time_ that’s how I would say_ I try to_ yes to_ do research at the university of applied sciences.” Among non-university research institutes research is regarded as the main field of work. “Yes_ the majority_ I do research_ as I am at a non-university research institutes _ this is my main area of work.” The interviewees mentioned a couple of tasks among the field of research.

The first task is *project acquisition*. “Yes, on the one hand, of course _ I try to communicate with other researchers_ like you are doing it right now_ I try to understand what do they need.”

Almost every interviewee stressed the important role of google for *literature search*: “Google is – quasi – my best friend_ the first time if you have just a couple of keywords_ simply search for it and see all relevant work.” “If I have no idea I use Google Scholar to understand a topic_ by regarding a citation network_ it is less literature databases which out library offers.” “Ah, it’s the question where I get my literature from_ I would say about 90% google scholar indeed.” Furthermore one researcher stated: “You can see, there are enough books here_ it is not that books have lost their meaning_ the digital word misses the filtering function_ I have no problem that the digital world exists, but it makes science more difficult, not easier.[...] the difficulty results from the vast amount.” One interviewee claimed, that books contains the basics of a discipline and therefore belong to research as well.

Further steps of *literature search* are carried out among online databases like Web of Science, Mendeley, Scopus, EBSCO, Science Direct or AIS. Among the phase of *data preparation* tools like Citavi, Mindjet or MAXQDA are in use. “I like to use any kind of mind mapping software_ in order to visualize the structures_ Mindjet MindManager 2012 as my employer licensed that tool.” Still very simple tools like paper and pencil are relevant too. “The very basic idea, yes_ with paper and pencil_ that can be formulas or sketches.”

Some interviewees referred to the task of *data analysis*. “And then I once did a data analysis with R and once with Rapid Miner._ But in most of all cases that makes no sense as data can be found in tables in excel and I can do a content related analysis.” “Another 20%, yes it might be 20%, which directly belong to data analysis as quantitative analysis_ that are tasks that are strongly supported by Excel and by SPSS for very simple analysis.” A research assistant of computer science gave a couple of computer languages and code testers like C++, Matlab, GitTab.

Writing is a very important task as it is one possibility to enable the spread and discussion of the findings among a (scientific) community and it takes place right after the *data analysis*. Disciplines making use of many formulas like computer science or mathematics tend to use Latex. In collaboration with other disciplines, Word or Google Docs are used as everybody is familiar with them. “I have to admit, nowadays I really like to use Google Docs.” In relation to writing, Endnote becomes used to control all citations, drop box enables the sharing of content, and Adobe Illustrator enables figures. According to the interviewees, there are always some shortcomings of the tools making other tools useful, e. g. Word does not provide good graphics, but Google Docs forces to give up the intellectual property. The presentation of results at conferences or workshops is another possibility to spread findings. Two out of the 19 researcher defined the *writing of reviews* as task among research.

Process: One research assistant holding a PhD precisely described his/her research process. “Doing somewhere a search among the library, conferences, downloading and reading publications_ sometimes colleagues call my attention to something_ classic_ let me say literature surveying_ what happens there_ regarding the quantity 20 up to 25%_ a second part is to prepare and search my data_ like reformatting_ make text machine readable and so forth_ and that maybe, let’s say an amount of_ about 40% of my tasks_ and another 20%, yes maybe 20% for the qualitative and quantitative analysis. A very small amount, maybe 10%_ to prepare a publication out of it_ that’s my workflow.” A second interviewee declared his/her research process as “chaotic”. “Yes, that’s a process of thinking_ [...] gather all the data_ finding reasons to gather data_ sometimes there is a circularity_ so you have to do it again_ that’s because_ you are entering a new field and that always has something of a process_ it is not easy to separate_ you have to be prepared to get surprised.” Both interviewees refer to the inherent process during carrying out a research. Another interesting process mentioned by two interviewees is the organization of the work in particular fields in the formation of waves. Regarding the different fields of work one interviewee reported: “If there is such a push_ that is an extreme amount of work_ you can do almost nothing else_ than you have to wait what happens with a proposal_ than other things get into focus_ therefore a quantification as you may want me to formulate for the end of the day_ that’s difficult.”

Communication: Even though there are as well opponent position concerning communication among researchers, all interviewees regarded it as important. “communication is a central part of my work” Regarded types of communication are direct communication, indirect communication and science communication. Science communication is on one hand, communication of content being defined as scientific knowledge and on the other hand for communication ways of the scientific community [9].

Direct communication: “That’s maybe a good example, but I am not sure whether it suits with communication_ if I am writing a publication with people and they do not belong to the institute_ what I do often is_ in the final phase of the paper_ one or two writing days where we meet in personal.” “We have a weekly meeting where the project status is discussed.” “Categorical necessary_ the creative process of developing research_ implies in any case_ the direct dialogue and can’t be replaced by electronic media” [...] there are regular meetings for example with the PhD candidates_ and I consider the regular lunch as very important_ that is important communication”.

Indirect communication: The main communication channel used in science is e-mail. “And a high amount of e-mail [...] of course we have discussions_ from face to face_ but_ a lot of things are negotiated via e-mail_ maybe 50 to 60 e-mails a day.” “First of all, there is e-mail as the most important communication channel we have” “Regarding organization_ than_ e-mail is the most important one_ from time to time_ personal contact_ but the most of all is negotiated via e-mail.”

Science communication: Science communication is increasingly realized via web 2.0 technologies. Publications are presented online increasingly. “as a team, we have a website which I entirely redesigned towards a blog_ and I am publishing there as well as my colleagues or sometimes even students_ [...] I have published there some conference reports_ when I was visiting a conference_ [...] that is a broad field of information.” “A colleague_ he is publishing an ant navigation blog_ I have read this sometimes.” “Sometimes when I am searching_ I am directed toward blogs_ in majority that

is useless_ it is only interesting in order to know about the topics someone is writing about.”

Virtual social networks: Virtual social networks are of interest, but maintained on a quite different level. “ResearchGate_ that is used to present research.” “Dissemination_ of course_ Mendeley, Twitter and ResearchGate_ that are the top 3_ a little bit of Facebook and Academia.edu” “I am subscribed almost everywhere but I never use that_ Xing and ResearchGate_ [...] ResearchGate I do not keep to manage contacts.” “Well I am at LinkedIn_ I have a profile there_ I do not care about that_ the majority of accounts exist in order to ensure nobody else uses my name.” “I am reproducing my contacts in social networks_ via Xing or LinkedIn.” “Concerning literature_ I realized_ that those networks have developed to a literature deliverer for literature, which is not open access” “What is additionally used_ that’s Xing in order to acquire people for enquiries [...] or developing contacts for acquisition of funding.”

Data Exchange: “And we have shared disks [...]” “For internal work we are using_ increasingly SharePoint from Microsoft_ that’s not Web 2.0 [...] enables an exchange of information besides e-mail.”

Collaboration: Besides one interviewee, all others agreed on the importance of collaboration. “I am not interested in exchange.” “In most of all cases_ I work with somebody else_ I have not published anything alone.” “I really prefer to do proposals together with someone else_ because_ there is somebody reflecting my things in a critical manner.” Regarding the development of collaboration, different opinions exist. “So_ it’s not going to increase [...] it is not an increasing number of participants among a cooperation project.” “My experiences in collaboration are very positive and among the last 5 or 6 years_ it has further developed in a positive way.” “Of course, that is necessary_ and it is supposed to be the aim of every professorship.” Collaboration is as well carried out with other disciplines. “Yes, with biology scientists, we have done a couple of projects [...] and historians.” “And demos allow to get in contact with other researchers from the university_ if they have visual data to show_ they are going to ask.” “We are working among a team of 2 or 3.” “The most intensive collaborate, that is among the team”

Conceptualization

One noticeable issue from all of the interviews was that the answers to the first question giving the chance to identify fields of work for every interviewee can be used as a first indicator to what extent a person was concerned with a particular field of work. As a first pattern, research assistants without a PhD did not mention administration besides one. Research assistants holding a PhD in contrast did not mention it in a first row, but in any case referred to administration. Scientists holding a higher degree often even mentioned it as the first field of work. Asking interviewees, whether a particular field like administration was a part of his/her everyday work life, all interviewees confirmed all fields. Besides, scientists who reported to be involved in projects (funding) described administration often as their main field of work. Based on all interviews it can be stated that besides research is perceived as important field of work and administrative tasks are taking a *lion’s share of time*. Professors in charge of being the head of an institute often reported that there is no more time for research by themselves. Besides, only two of the interviewees reported to use a tool in order to ease the organization of projects (ProjectPlace, Microsoft Project). For a further investigation it is necessary to gather more information regarding the *role* of scientists among (funding) *projects* and their involvement. Besides the

administration of projects there exists another group of tasks regarding the administration of the institution itself. For some disciplines, funding seems to be less relevant than in others, for example Mathematics, Computer Science, or Jura. Some researchers perceive funding projects and research as the same thing. That defines funding as an enabler for research among that disciplines. Only one interviewee told us to have a large international project with a need for collaboration with many partners. The respondent further reported, that he/she is using an online project management tool because it simplifies his/her work. As none of the others reported to do similar things that could be an indicator that the degree of *collaboration* and especially *international* one drives the usage of collaborative (online) tools. The impact of the two needs further investigation and is theoretically anchored among the theory of task technology fit. In contrast, one interviewee reported not use the computer besides communication via e-mails and as typewriter. That particular interviewee reported to have no funding projects and no collaboration.

For the process of research, a couple of steps have been extracted. Even though some of the researcher neglected a process, there are similarities to [8]'s model which might enable an extension with an IT perspective.

3. CONCLUSION

The presented research is a first and qualitative attempt in order to understand the usage of tools and the processes taking place. We extracted a couple of interesting findings and they will guide a further research among the topic.

Professional daily routine: Teaching, research and administration are fields of work for researchers. Some researchers consider funding as a part of research, some perceive it as a fourth field of work and some neglect to engage to raise funding. There is no repeated routine for every day, but there is a routine related to waves in which the fields of work become relevant.

Human: Furthermore, the fear of losing the intellectual property belonging to the characteristics of the *researcher* (intention to use) was mentioned a couple of times. The second issue complies with the mode of [13], but it further confirmed that the intention may not be the only driver for a usage itself.

Task: *Collaboration* and *internationalization* are characteristics of tasks that need further investigation in order to quantify their impact on tool usage. From the first step of our research it seems to be that collaboration and internationalization are task characteristics that lead to a broader usage of web 2.0 technologies.

Role as characteristic of the scientist among projects appears to be another driver for the design of everyday work live of researchers. By definition, leadership of projects enhances the administrative effort and herewith reduces the resources for content related work. In order to reduce the effort for that field of work, a support by tools should be further evaluated. Furthermore, a couple of *tasks* appearing among the *field of work* of research could be identified. But the support happens by separate tools. A centralized platform is missing, which covers just more than one task among the research process. Many of the described tasks besides search for publications are still mastered in desktop software. Regarding the

transformation of a process towards a usage of online tools, there are *task characteristics* influencing usage: again, collaboration plays an important role. Relating to the topic, science is still carried out in the majority of tasks without *e*.

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