Results of Knowledge Audit in a Scientific Collaboratory: Possible Applications of Selected KM Aspects in Scientific Collaboratories

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Abstract: The paper discusses possible applications of selected aspects of knowledge management in the field of collaboration in science and research, which is characterised by a high degree of knowledge specialisation. Specialised knowledge becomes productive only if combined into comprehensive knowledge that creates the need for scientific and research collaboration. Attention is paid to the so-called collaboratories, which have moved their role from efforts to share tools to sharing scientific data and related knowledge. The newest technology-based collaboration instruments cannot overcome the issues if working with people and their motivation to collaboration is neglected. Practically, the paper describes implementation of KM expertise in the KNIHA SK Project Collaboratory specialised in rescue, stabilisation and preservation of traditional information media in Slovakia, using the scientific method of knowledge audit. The general recommendations and examples from the knowledge audit's implementation have been adjusted to match the environment of scientific research and cooperation and they were applied to a sample of about 100 members of the Collaboratory. The analysis also included measurement of productivity in the form of publishing output and co-authorship of scientific papers. The results of the knowledge audit focused mainly on the deficiencies found out are quite material and hence described in more detail. The paper proposes general recommendations for the management of inter-institutional scientific collaboration. Such preparatory phase should be seen as one of the most important stages of a collaboratory's life and sufficient time should be allocated for preparation and adoption of common standards, confidentiality agreements should be entered into with all members of the collaboratory, and the focus should be set on the quality of knowledge organisation and aspects of information ecology.

Keywords: scientific collaboration, collaboratory, knowledge audit, knowledge management, scientific collaboration recommendation

1. Introduction

Social and economic changes have, inter alia, called for a change in the management of organisations that focus their attention on knowledge. Among the first companies that made attempts to apply the theoretical background of knowledge management (KM) into practice, were large American companies dependent on the work with their intellectual capital. The changes brought about by the knowledge society and knowledge-based economy must be faced by both private and public sectors. According to OECD (2001), knowledge becomes a critical determinant of competitiveness for public sector too. In the knowledge economy, public sector organisations compete in a certain way within their fields at national and international levels. At the international level, there is competition with foreign organisations offering similar services. Research institutions compete to attract the best researchers and funding, and universities are in increasingly bigger competition to attract investment, the best students and teachers. Goods and capital are not of such importance for the public sector like for the private one, but knowledge is equally significant in both sectors.

The area of research and development (R&D) can be found both in private and public sectors, because a long-term survival of any company depends on its ability to create and explore innovative ideas, to bring to market such products or services that differ from their competitors. During the recession, companies cut their costs to survive. Something which companies cannot just cut blindly is investment in R&D, because as soon as the recovery phase comes, the competitive advantage will be in the hands of those who have invested in R&D (Rosenthal, 2009). The area of R&D is highly knowledge-intensive as regards both explicit and tacit knowledge. While information, knowledge and the way how this wealth is managed are important factors for success of any organisational function, they are crucial for further ability of the field of research and development to fulfil its primary roles. The main functions of R&D in a modern organisation suggest proximity to the principles and practices related to KM. However, the reality shows that there were only few KM "incursions" into R&D community (Lelic, 2003).

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2. Collaboration in science and research

New innovations and technologies can emerge anywhere in the world and are more likely to arise from open networks and cooperation than from a lonely institution. One of the many consequences of social change that is necessary to take into account scientific cooperation is gradual specialisation of knowledge. P. Drucker (1994) argues that knowledge is effectively applied only in highly specialised cases. However, specialised skills can become productive only if combined into uniform, comprehensive knowledge. Everything has got its advantages, but also disadvantages. Organisations dealing with science and research are therefore constantly deciding whether to launch research just by themselves, or jointly with others.

It is understandable that knowledge sharing is more natural within organisations than among organisations, and, likewise, intra-regional cooperation is more natural than cooperation among regions. On the other hand, cooperation among a large number of specialists from different countries is required for new unique innovative solutions. How can this situation be solved?

Studies on economic geography differ in statements and give no definite answer. Some argue that the acquisition of knowledge from geographically distant sources is very complicated due to the ability of companies to build their further innovations on non-local knowledge (Thompson, Fox-Kean 2004). Other research conducted in 2005 (Penner, Shaver) found out that companies carrying out international research tend to produce more patents than those with domestic research.

Also interesting was the analysis done by Leiponen and Helfat (2006), who found out that the benefits arising from scattered research do not lead to genuine innovation, but merely imitative. Potential gains from access to diverse ideas and expertise from different geographic areas are offset by the complexity in integrating this knowledge across multiple geographic territories.

Problems can also be observed in multi-disciplinary research. Scientists from different disciplines were usually trained in different departments, have had different consultants, publish in different journals, and attend different conferences. This creates a tension between the benefits of innovation, which are based on working together across disciplines and organisational boundaries, and the risks arising from the costs of coordination and building relationships within such cooperation. The existing literature provides no clear guidance as to coordination and establishing relationships in multi-disciplinary collaboration (Cummings - Kiesler, 2005).

3. Collaboratories

The issues of geographical distances are a frequent phenomenon in large research projects. Time and travel costs, problems with maintaining contacts with other scientists, checking devices used for testing, distribution of information and a large number of participants in the research project represent some of the problems which scientists must face. Thus, models of so-called collaboratories begun to develop, in response to the problems and limitations mentioned. However, the development and implementation pointed out that it is not a cheap item of the budget (Sonnenwald, 2003a). Difficulty and specificity of collaboratories will also show in a situation where highly qualified scientists who have little experience in leadership and management will suddenly find themselves in a situation in which they are responsible for leading people in a virtual environment.

From the viewpoint of processing the concept of collaboratories it may be interesting to determine uniquely the relationship between the concepts of collaboration and cooperation which are sometimes interchanged. Dillenbourg et al. (1995) provide one possible differentiation: “Collaboration" is distinguished from "cooperation" in that cooperative work "... is accomplished by the division of labor among participants, as an activity where each person is responsible for a portion of the problem solving...", whereas collaboration involves the "... mutual engagement of participants in a coordinated effort to solve the problem together.

William Wulf first described collaboratory as a centre without walls, where researchers of a given nation can carry out their research irrespective of their geographical location – while interacting with colleagues, having access to the equipment, sharing data and computing resources, accessing information in digital libraries (Wulf, 1989). A wide-ranging definition was offered by D. L. Cogburn, who stated that "a collaboratory is more than just an intricate collection of information and communication technologies. This is a new cross-linked (networked) organisational form, which

involves social processes, technology cooperation, formal and informal communication, and consensus on norms, principles, values and rules" (Cogburn, 2003).

A simplified form of the definition describes collaboratory as an environment in which participants use computer and communication technologies in order to obtain access to shared data and tools, as well as for mutual communication purposes.

The distinguishing feature of collaboratories is that they focus on collecting and analyzing data. This means that they focus on the application of collaborative technologies to support data sharing, which is a contrast to sharing tools. Chin and Lansing (2004) examine the shift from development of collaboratories from the traditional approach focused on sharing tools to an approach which is oriented more on data and support of data sharing. This represents more than just a provision of a common repository for storing and retrieval of shared datasets. According to Chin and Lansing, cooperation is also driven by the need to share data, and the need to share knowledge on them. Shared data is only meaningful a sufficient context is given to the data so that they can be understood and effectively applied by collaborators. Therefore, according to Chin and Lansing, it is necessary to understand how datasets relate to the aspects of the overall data space, applications, experiments, projects, etc.. It is important to know the conditions of a scientific experiment or research in which the data was created, the data's origin, i.e. the relationship with previous versions, data integration - the relationship of a subset of within a whole dataset and the like.

K. J. Lunsford and B. C. Bruce (2001), suggest the following attributes of the collaboratory which can be regarded as the main ones: Collaborative Inquiry - participants have got not only common, but they share a common set of problems or issues; International character - it tends to be recognised by stakeholders as a joint venture, there is a shared awareness of the status as a mutual project; Active participation and contribution – this exists to such extent to which its members use it, and, more importantly, to which they add resources to it; Access to shared resources – it provides unique information (data, links, research findings) and tools which its participants need; Technologies - usually Web-based, Boundary crossing – collaboratories bridge geographical, temporal, institutional and disciplinary gaps.

It is quite a frequent phenomenon that a collaboratory develops from a scientific research team, and later, after achieving a goal, the group does not fall apart, but continues to work as a scientific research community, whose main characteristic is an interest in further cooperation in the field without a well-defined common goal.

A collaboratory consists of researchers and there is rarely a leader who is educated in the field of management. It is a benefit if the person in charge has got some project management skills needed to manage the collaboratory. Moreover, the person responsible for leading the collaboratory must be aware of all the specific aspects of inter-institutional and sometimes interdisciplinary body in which every member can come from a different socio-cultural background with different customs and behavioural culture. In addition to these aspects, there are only technological collaborative tools available to create a good atmosphere of cooperation and enthusiasm for achieving a common goal. It is therefore very important that the process of making decisions in a virtual environment was as transparent as possible, especially in case of complex decision making. (Duarte et al. 2001).

A common problem is that a prevailing part of preparation of a collaboratory is devoted to the issues of authorising access to internal and external data, which evokes an atmosphere of fear and concerns about "siphoning off" intellectual capital. This creates a paradoxical situation, or a so-called tension field (Borges, 2004) which arises when it is necessary to share knowledge and to protect them from seizure at the same time. How is it possible to create, within a collaboratory staffed by employees of various institutions, an atmosphere of trust and to have no concerns about disclosure of the results of the activity? It turns out that more attention should be paid to persons handling the knowledge which requires protection than to the protection of information/knowledge systems, buildings, documents and so on. Things like tacitness, novelty and specificity of knowledge, trust, geographical distance, cultural differences, partners' experience with cooperation, size of organisation which we cooperate with and the like are the factors that have got an impact on the direction in which this paradoxical situation of cooperation and protection of knowledge moves. This situation obviously requires legal protection measures to secure the results of research work in a collaboratory.

Bos et al. (2008) defined 3 types of barriers in collaboration. The first barrier is the fact that scientific knowledge is hard to combine. This statement is based on the nature of knowledge which is considerably different from information. Knowledge requires a broad context and once it is externalised it is not complete as before the process. As the authors indicate, information can be transferred and stored easily, unlike knowledge. Understanding knowledge often requires previous knowledge and experience. Therefore, scientists are also not sure in collaboration whether their knowledge will be understood correctly. The second barrier is the fact that scientists are used to working independently which they enjoy. Researchers have got more freedom to pursue high-risk ideas and strongly resist controls. This feature makes it more difficult to aggregate labours of scientists. The third barrier is the demanding nature of cross-institutional work. Managing the boundaries among institutions is more often a greater barrier than the actual distance (Cummings - Kiesler, 2005). Although all scientists are prepared to collaborate, problems often occur in relation to parent institutions, especially problem related to legal issues (regarding intellectual property). Unfortunately, we have also encountered all the types of barriers in our effort to implement KM principles in the scientific collaboratory.

4. Implementing knowledge management in the KNIHA SK collaboratory

4.1 The KNIHA SK collaboratory

The research was focused on the implementation of KM in a selected collaboratory called KNIHA SK - Rescue, Stabilisation and Preservation of Traditional Carriers of Information in the Slovak Republic, 2004-2009, which was a project implemented in the conditions linking together research and higher education (Ministry of Education of the Slovak Republic and Slovak University of Technology), the Slovak National Archives (SNA), the Slovak National Library (SNL) and the Slovak Academy of Sciences (SAS, Institute of Polymers). The Collaboratory was founded in 2003, when the parties agreed on collaboration in order to concentrate the Slovak Republic's scientific potential in the technology for rescue, stabilisation and preservation of lignite-cellulose (LC) macromolecular materials. An agreement was concluded by representatives of the University, SNL, SNA and SAS. The goal was to create long-term perspective cores of interdisciplinary teams that will be a guarantee of continuous qualitative improvement of solutions and an important role in this area in the future.

Intersection of the KM concept in science and research is not frequent, but necessary as the creation of new scientific evidence is one of the main tasks in the case of the KNIHA SK consortium.

4.2 Analysis of publishing output

Measuring productivity (numbers of publications, presentations, patents etc.) is one of the indicators of a collaboratory's success (Shrum, 2001). From our point of view, we considered it important to observe co-authorship of the collaboratory's participants.

Before the knowledge audit was carried out, we had conducted a preliminary research by analysing the publishing output of the KNIHA SK collaboratory's members in 2006 and 2009 as regards **co-authorship and inter-institutional cooperation**. Within this part of the research we also sought an answer to the question: who are the key stakeholders in collaboration in the KNIHA SK Project?

Based on the analysis of data on publishing output of the KNIHA SK Collaboratory in 2006 and 2009, we prepared summary tables with the results, and on the basis of the data we extracted final calculated figures provided in Table 1, which represents the number of published papers per person from a given organisation.

Table 1: Average number of papers by collaboratory members in each collaborating institution in 2006 and 2008

Institution	Average annual number of papers per person	
	2006	**2009**
STU	6.1	7.1
SNK	5.5	6.6
SNA	7.0	7.3
SAV	7.0	2.0
Average	6.4	5.8

It can be determined using the data in Table 1 that in total numbers the publishing output per one project researcher decreased over the three-year period examined. However, if we take a closer look, we will find out that cooperation improved in three institutions, while it dropped remarkably in one of the institutions (SAV). We have identified the causes of the decrease at a later stage.

Improved publishing output in most institutions does not necessarily imply better collaboration among authors, as indicated in Table 2, which suggests that the co-authorship and inter-institutional collaboration index decreased. While in 2006 the co-authorship index was 2.83 authors per one publication, in 2009 it decreased to 2.48. Similarly, the inter-institutional collaboration index which was 1.52 institution per one publication in 2006, dropped to 1.35 in 2009.

Table 2: Development of co-authorship and inter-institutional collaboration in the KNIHA SK collaboratory in 2006 and 2009

Year observed	2006	2009
Co-authorship (the sum of co-occurrences of publishing authors from the Collaboratory divided by the number of publications)	(153/54) 2.83	(129/52) 2.48
Inter-institutional collaboration (the sum of co-occurrences of collaborating organisations divided by the number of publications)	(82/54) 1.52	(70/52) 1,35

Despite the longer duration of the collaboratory's life and increasing publishing output of the researchers, cooperation in writing does not increase, but rather decreases slightly. As the collaboratory is in operation since 2004 and the project tasks were completed as of the end of 2009, we expected that cooperation would be improved based on the knowledge about the dynamics of virtual teams. According to Henry and Hartzler (1998), the following basic stages can be observed in collaboratories:

- uninformed enthusiasm
- informed enthusiasm
- paralysis
- providence
- energy for working well-informed

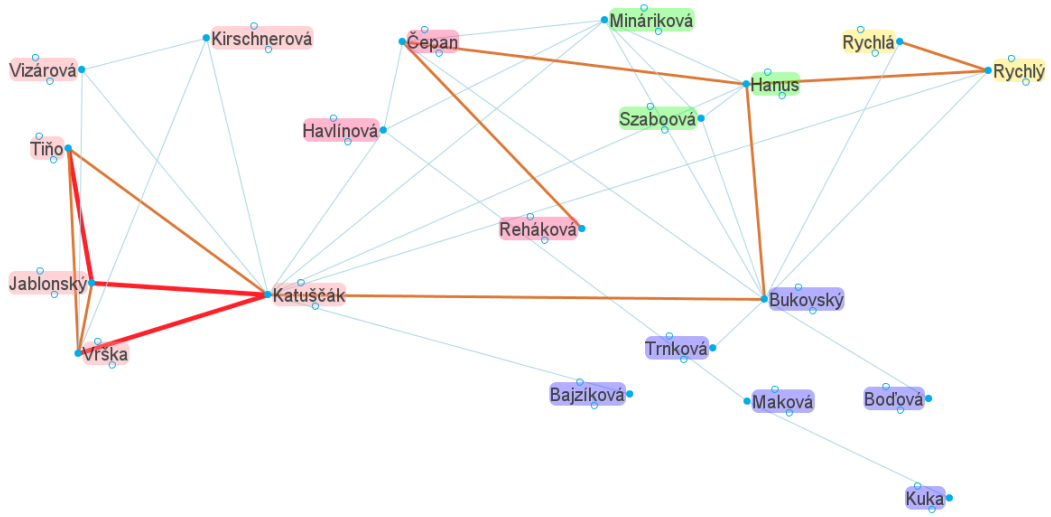
Scepticism should fade away, and researchers would work in a well-informed and enthusiastic state. The assumptions are based on several conditions which have not been met. With the passage of time, trust, researchers' involvement, transparency of decision-making etc. should improve. Particular causes will be easier to understand by looking at the knowledge audit's results.

In the next step, we observed cooperation of individuals from the different institutions. The outcome had a form of the collaboration incidence matrix which provides the number of publication in which a given author participated, and the number of authors who she or he collaborated with. Since it would not be practical to observe the goals in a relatively complex table, we have made an attempt to provide a graphical visualisation in Figures 1 (2006) and 2 (2009).

For better legibility, we only included authors with a minimum number of two publications, who have cooperated in writing at least two publications with another author (co-authorship). We have distinguished the affiliation of the authors by colours representing their parent institutions.

Based on the figure showing the intensity of cooperation within the collaboratory among most active authors, we can conclude that in 2006 STU was the most active institution in terms of cooperation, and in 2009 it was SNK, surprisingly. The above-mentioned reduced publishing output of SAV can also be seen in this figure, since no connecting line is directed to that institution.

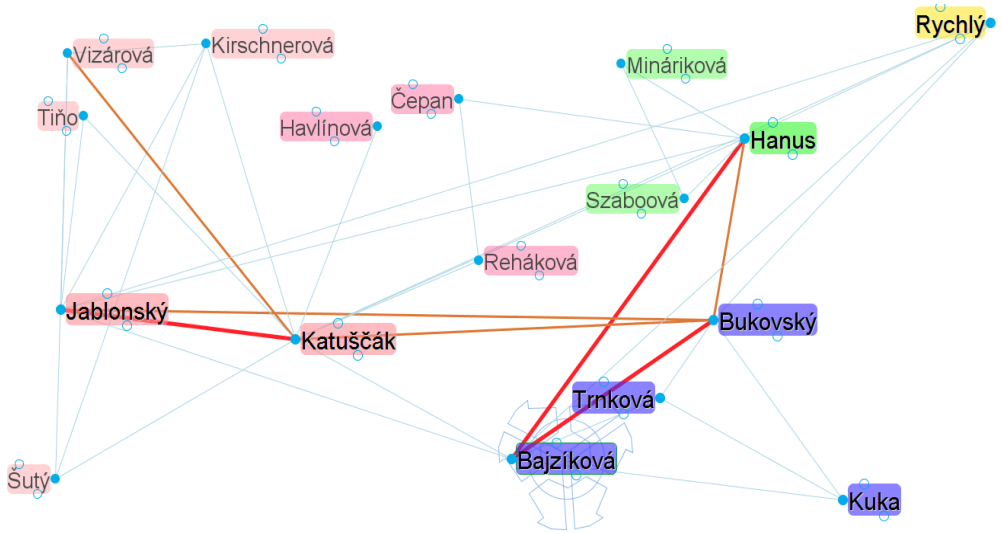
By comparing the figures it can also be found out that there are no fixed co-authorship groups who would participate jointly in preparation of papers, as Figures 1 and 2 differ significantly. The issue of geographic boundaries as pointed out by many authors, appears to be minimal in this collaboratory, since the only geographically distant institution (SNK) is more active in joint authorship than the geographically closer institutions SAV or SNA. Based on the intersections of the two figures we can obtain a partial answer to the research question about who the key stakeholders are in the collaboratory.



Legend – number of co-authored publications

7 and more
5 – 6
2 – 4

Figure 1: Visualisation of co-authorship of the KNIHA SK Project researchers in 2006



Legend – number of co-authored publications

7 and more
5 – 6
2 – 4

Figure 2: Visualisation of co-authorship of the KNIHA SK project researchers in 2009

4.3 The scientific method - knowledge audit

Knowledge audit is an important preparatory stage of an initiative or a program of KM implementation, and its ultimate outcome is a detailed report which provides scientific evidence based on which knowledge management teams and senior staff responsible for decision-making may make informed decisions concerning improvement of knowledge life-cycle and knowledge flows. The knowledge audit report allows visualisation of the acquired findings in the form of knowledge maps (Hylton, 2004). The term of knowledge audit is inadequate in a certain way, because the traditional role of an audit is to find out about performance against some standards like in the case of a financial audit. A knowledge audit is a more qualitative assessment, and a phrase is often mentioned that indicates the content of the knowledge audit, which aims to be "an investigation of the health of knowledge in an organisation" (Lingham, 2006). The knowledge audit, just like any other audit, is a tool for scientific investigation and research. A. Hylton states that knowledge audit is a systematic scientific investigation and evaluation of explicit and tacit knowledge resources in an organisation. Knowledge audit examines and analyzes the current knowledge of the environment, which completes the diagnostic and prognostic report on the current "health state of knowledge" within the organisation. The report provides evidence whether the organisation's knowledge potential is maximised (Hylton, 2004). Knowledge audit should identify where exactly intellectual capital is generated, reveal previously uncharted knowledge flows, qualify the relative value of knowledge of individual employees, identify those skills that still remain hidden (tacit) and, especially, it should greatly facilitate the implementation of subsequent KM phases (Vymětal, 2005). Various methodologies of knowledge audit can be found, such as D. Skyrme (2002), J. Liebowitz (2000), S. Burnet (2004), (Hylton, 2004) and H. Jones (2005).

In the KNIHA SK collaboratory we decided to apply the knowledge audit method proposed by N. Chowdhury (2006), which appears to us as simpler and easier to implement in the area science and research. The research had the following intermediate objectives

- Identification of knowledge needs - what knowledge does the collaboratory and its experts possess and what knowledge is needed in the future to fulfill their goals and tasks;
- Analysis of the knowledge inventory – the knowledge warehouse`
- Analysis of knowledge flows (movement of knowledge resources throughout the organisation);
- Synthesis of the knowledge acquired - creating a knowledge map.

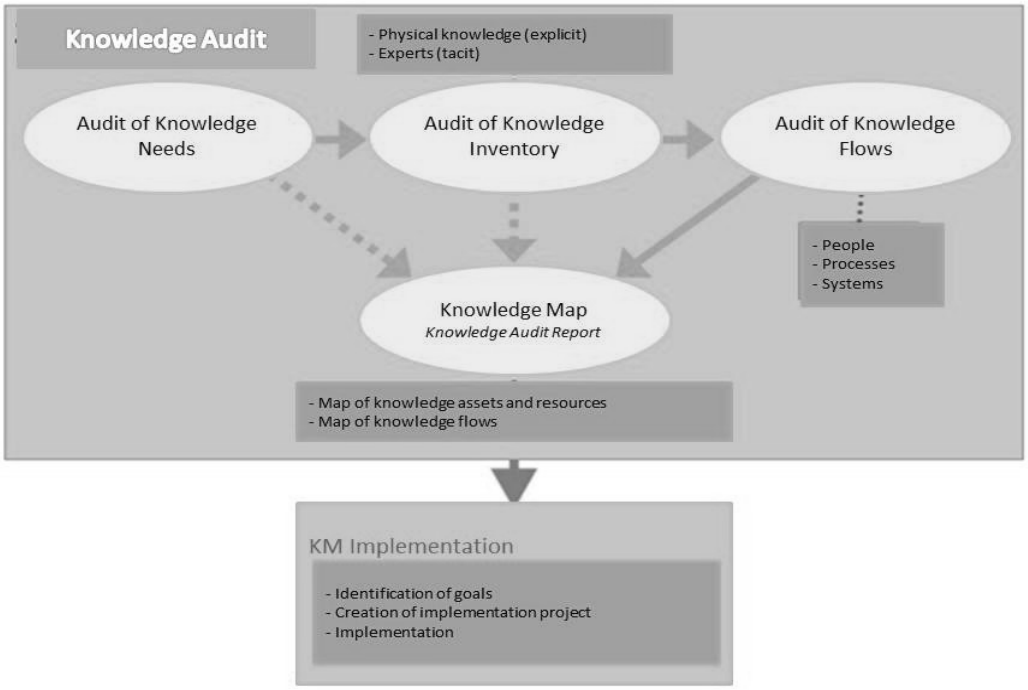


Figure 3: Knowledge audit components and processes

4.4 Procedure and findings

To obtain the necessary information, we used the method of questionnaire, interviews and focus group interviews with senior management. The questionnaire was posted on the shared KNIHA SK Collaboratory's portal and the request for participation was sent out by e-mail two times with some delay. Only 17 researchers out of 40 were willing to reply, which was the first sign that the interest in cooperation and solving common issues was low. The respondents included scientists and researchers from the abovementioned institutions dealing with conservation of historical documents.

Under the part of identification of knowledge needs we found that many members lack access to selected specialised databases. Most of them stated that they do not always manage to find what they were looking for in the Collaboratory's information system (IS). Similarly, most respondents admitted that they rarely make use of the shared resources contained in the Collaboratory's IS. Interestingly, it was found that according to the persons surveyed, most important knowledge is in the minds of the Collaboratory's members than in the IS. The results indicate that the largest quantity of knowledge is hidden in the minds of the members, slightly less in the personal computers of researchers, then in the researcher's paper notes, and least in the Collaboratory's IS. We found out that researchers "do not have time" to store their findings, which may be caused by poor common standards of common work with information, or the complicated system, which is regarded by most senior scientists as not intuitive. Several members pointed out that the system is not transparent and that the taxonomy of shared documents was changing too often.

Under the part of analysis of knowledge flows we found that cooperation among the Collaboratory members is at a low level. Poor awareness about activities of other colleagues in the Collaboratory turned out to be a big problem. The common goal was artificially divided into sub-problems, which meant that researchers mainly worked individually, and the expected benefits from the synergistic effect were not achieved. It can be said that it was more cooperation rather than collaboration. The members also lost their enthusiasm and acknowledged that they often prefer their personal goals (publications) to the common goals of the Collaboratory. The problem may be that members admitted that they were not quite sure whether their colleagues are willing to publish all their results (both positive and negative).

Under the part of analysis of knowledge inventory we studied a non-public web application available to registered users only, sorted into folders, providing secure sharing of documents to support solving the tasks as well as partial results. It turned out to be a problem that the taxonomy of folders was often changed, that the system was not transparent and that full-text searching directly on the server was difficult. We analysed the Knowledge Database of Results of Basic and Applied Research, which should inter alia contain all the knowledge on the subject of the project's research available at the time. However, there was a problem with relatively poor filling of the database and, especially, lack of confidence in the quality of the data shared.

The last phase of the knowledge audit was to create a knowledge map. We decided to use a radar chart (Figure 4) and the information acquired were divided into eight groups (we provide the types of questions included in the questionnaire which concerned the given category):

- Know-what (e.g. the level of one's own theoretical knowledge in the area);
- Know-how (e.g. the level of one's own practical experiences, best practices);
- Know-who (the knowledge on whom to consult with a problem, knowledge on what colleagues deal with);
- Know-why (own interests such as publication activity is preferred to en effort to make a patent, i.e. goals of the collaboratory) ;
- Sharing (perception of the degree of cooperation; use of documented procedures from colleagues);
- Trust (in repeatedly used resources, in moral behaviour of colleagues from the viewpoint of research);
- IS as a shared communication tool;
- IS as a knowledge warehouse.

Based on the data obtained, we mapped the answers to numeric values needed to create the knowledge map. Then we calculated the average scores under a category which we expressed in the knowledge map.

Table 3: Mapping answers to numeric values

Value in the graph	Positive questions / negative questions	Time-related aspect	Score range (average from the respondents)
0	Strong disagreement/strong agreement	Never	(0-0.99)
1	Disagreement/agreement	Rarely	(1-1.99)
2	Neutral attitude	Quite often	(2-2.99)
3	Agreement/disagreement	Very often	(3-3.99)
4	Strong agreement/strong disagreement	Constantly	(4)

In each group, we used a four-level scale to determine a level achieved by the Collaboratory, and the level that we could achieve through implementation of KM in the Collaboratory. No category reached level 4 and in the given situation we expect that it will not be reached even when KM knowledge is implemented in the KNIHA SK collaboratory's management, and we suppose that it would have been more efficient to implement it in the introductory phases of collaboration.

The knowledge map shows that the biggest problem of the Collaboratory is the IS, which was not used as a common communication tool, low level of know-why and low confidence, which affects the poor level of knowledge sharing. By examining the knowledge acquired, we have formulated recommendations for the KNIHA SK Collaboratory in three areas: knowledge-based collaborative technologies, intelligent tools for knowledge organisation, social aspects of collaboration.

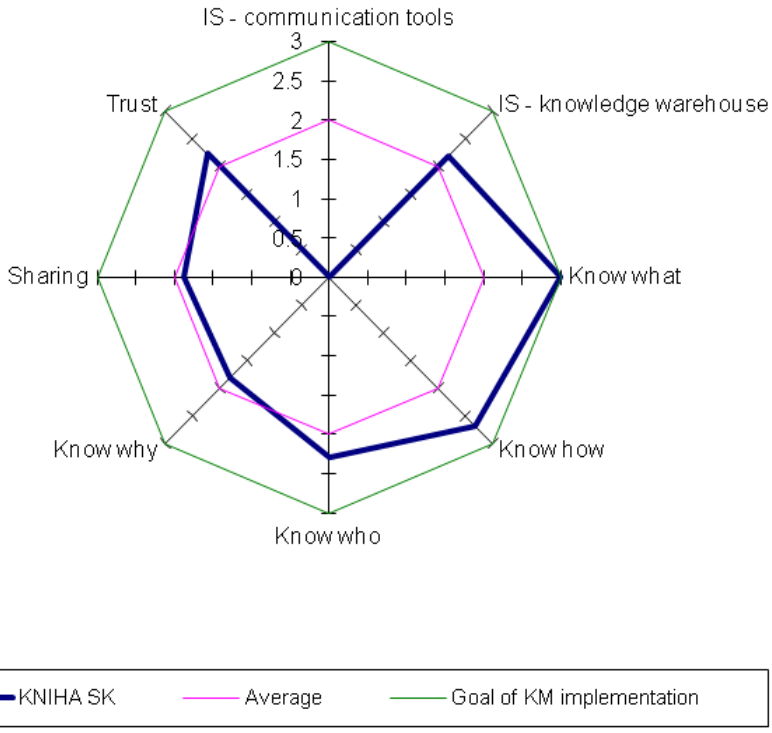


Figure 4: Visualisation of the knowledge audit results

The main findings of the knowledge audit:

- The potential issues of collaboration which start with actual willingness or rather unwillingness to collaborate, to share one's knowledge with someone else from a different organisation, and not to see such a person as a competitor – did not receive enough attention.
- The importance of personal meetings and workshops was underestimated, counting on the fact that they can be substituted with high-quality ICT. The project management did not realise the fact that if we rely upon collaboration in a virtual space, more attention should be paid to creating an

atmosphere of trust (both emotional and cognitive), and that technologies only represent a tool for supporting remote collaboration and cannot be regarded as a ready-made collaboration solution.

- A collaboratory's information system uses a shared digital library, a shared knowledge space and an Intranet communication system for the researchers. We did not succeed in finding the most up-to-date options in this system for collaboration offered nowadays by the Web environment. As the information system's administrator stated, the most used part of the system was the shared data space of the four collaborating groups available constantly from any Internet-connected computer. The Internet communication module or the discussion module is not used so far, and the researchers prefer other forms of communication, i.e. they communicate outside the Collaboratory's information system.
- The information system used in the Collaboratory, which should approximate features of a knowledge portal, corresponds with the culture of collaboration, the way of perceiving knowledge, the terminology, the system of thinking etc. is only suitable for the institution that has created it. When building the system, the organisation did not make any efforts to investigate the views of other members of the Collaboratory concerning the system characteristics. Researchers from other organisations have to adapt to the system, or minimise cooperation. For example, if the taxonomy of documents used on daily basis is demanding and changed frequently, users "adapt" themselves to that – they transfer the documents they need to their computers and visit the joint system very rarely, or if communication is required, they use their organisation's electronic mail system etc.. As the time passes, the common goal of the Collaboratory starts to fade disappear, and researchers often have got no idea what partial task their colleague from another institution is working on, and the interest in using the shared system or in the actual collaboration fades away.
- Yet another frequent problem observed is the different perception of the knowledge sharing process in each of the researching organisations. If one organisation is focused on creation of patents, which means that it promotes strict protection of knowledge and sees knowledge sharing as a knowledge market, and another organisation considers knowledge sharing as something natural, implemented via knowledge communities, then their mutual collaboration is complicated.

Based on the experience we have developed general recommendations for the designing and managing scientific collaboratories.

- Perceiving the preparatory phase as one of the most important stages of the collaboratory's lifecycle

It is the initial phase which is of utmost importance for the whole collaboratory to operate. If this stage does not receive enough attention, then the whole project can fail. This phase cannot be artificially reduced, it is necessary to devote as much time to it as required, otherwise it may have a negative impact during the project. It is essential that extensive discussions are held on the tasks of individual members, if necessary, to identify specific roles and responsibilities of each member. In case of virtual collaboration it is inevitable to identify targets and compliance on individual roles and responsibilities

- Establishing a function of the collaboratory's coordinator

The coordinator must be aware of all the unique aspects of inter-institutional and often interdisciplinary cooperation in achieving common objectives. This person must be able to identify conflicts, often only using web collaboration tools, and to resolve them operationally, she or he must check whether the objectives and deadlines are met etc., and yet leave other researchers with a feeling of certain autonomy. The coordinator should create a creative atmosphere with a certain tolerance of mistakes, try to change a possible culture of individualism to a culture of knowledge sharing, by motivating those who contribute the most to sharing, and motivate and reward them in other ways than with money. Motivation is quite complicated. It should be noted that it is a mental process that is determined by an individual's situational and individual variables (Príglová, 2008). An ideal situation is when members of a collaboratory feel the importance of their work for the overall objectives, and on the basis of such attitude, they do not forget their roles in the collaboratory at the expense of everyday tasks which they must perform meet in their parent organisation. The coordinator must be given sufficient time to prepare approval of common standards on the use of technology, methods of communication, ways of sharing knowledge, informing about new facts, and ways of approval of decisions, ways of protecting information and on communication of the collaboratory's results externally. If we want to coordinate researchers with different cultures and traditions, and ensure that their virtual communication is effective, then the preparation of standards is very important. Standards can help us make processes in a collaboratory more transparent, and reduce the possibility of conflicts and misunderstandings.

- Allocate enough time for preparing and approval of common standards

In the introductory stage, ***technology use standards*** (what types and for what purpose), ***standard***s ***concerning communication methods*** (what communication tool is to be used in specific cases, where to share important information, whether information will be sent to all members by a „push" technology such as email or posted in a portal), ***standards concerning knowledge sharing methods*** (where to place specific types of data, information and knowledge in a shared space and how to communicate about it, how often or under which extraordinary circumstances personal meetings are to be held etc.)***, standards concerning methods of informing about new facts*** (in what ways will information be shared and how often it is necessary to check e-mail or the portal's home page), ***standards concerning the methods of approving decisions*** (who decides what, which decision require agreement of all or most members, who presents and to whom etc.), ***standards concerning information protection methods*** (to whom the agreement on information protection applies, what information is confidential, what sanctions there are in case of a breach), ***standards concerning external communication on the collaboratory's activity*** (which information, in which manner etc.). After some time dedicated to discussion it is necessary to achieve acceptance of the standards' contents from all members. If we intend to coordinate researchers with various cultures and customs and make their virtual communications efficient, then it is very important to prepare the standards, which can assist us in making collaboratory processes more transparent and avoid any potential conflicts and misunderstandings. It is suitable to designate a person responsible for inspection of compliance with the standards, and sanctions for non-compliance, if any.

- Conclude a non-disclosure/confidentiality agreement with all members of the collaboratory

Without a similar contract, no knowledge is shared but just technology, digital library and potentially research results. As some members may have some concerns, despite the agreement, that some inexperienced members may inadvertently disclose the protected knowledge, it is important to organise training, for example on methods of industrial espionage.

- Focus on the quality of knowledge organisation and aspects of information behaviour

We recommend combined use of taxonomies with full text searching. Current knowledge of information behaviour can help in the proper setting of the collaboratory's IS and its security so that members do not feel information overload.

- Pay attention to the selection of the most appropriate "knowledge" technology

When selecting the latest knowledge of technology is important that their benefits and the way they work are explained sufficiently to al researchers and all investigators, and to find the common consensus. The use of such technologies is essential in the collaboratory, as members will often contact and consult each other, and also share their measured data, information and knowledge only with the help of technology. In selecting new technologies, their simplicity is of key importance, as well as intuitive interface, intelligent management of data, information and knowledge, good collaboration tools, group work tools - groupware, high-quality visualisation and other. A best solution seems to be a creation of a common "knowledge" portal, which will be a single access point for researchers to content, which will also helpful for posting important announcements, invitations and alerts on the main page.

- Other activities needed

The quality of culture and smooth operation of the selected technologies must receive attention throughout the entire duration of the project. The coordinator is responsible for monitoring the collaboratory's operation, and sees if some members are not excluded from cooperation. By tracking communication activity on a discussion forum, chat rooms, or by analysing e-mails, a social network analysis can be elaborated. The coordinator should follow observance of standards, transparency in decision making, and frequency of personal informal meetings, and perceive natural stages of the collaboratory's life, and, depending on the current stage, the coordinator should choose a mechanism to mitigate any negative moods and re-launch the interest in common goals, convince members of their deliverability, relevance etc. For example, for a stage of paralysis it is recommended to implement a knowledge audit to determine what sources of information and knowledge available to the Collaboratory's members are actually used, which are not used and why, and suggest pooling of resources in which researchers are still interested. Likewise, the knowledge audit can identify any problems with the culture of sharing, trust or with the operation and use of "knowledge" technologies, and propose appropriate solutions for launching further works in the collaboratory.

Since we now participate in implementing a collaboratory under the Memory of Slovakia Project, these findings we will be very helpful. It is a project of the National Centre of Excellence in Research, Preservation and Accessibility of Cultural and Scientific Heritage with internationally recognised basic research, which will contribute to improving the technical infrastructure of leading research institutes in the field of protection and access to cultural and scientific heritage in the Žilina Region, as the current level of technical infrastructure does not allow to implement a number of research activities at the appropriate level of quality, or does not allow to implement these activities at all. The project implementation will improve significantly the conditions of educational process and training new generations of researchers.

5. Conclusion

Our efforts to implement elements of KM in scientific research collaboratories can be evaluated positively. We were able to carry out a knowledge audit to highlight the very significant errors of the Collaboratory which would not otherwise be disclosed, and would decrease the Collaboratory's efficiency implicitly. By focusing on aspects of knowledge work we can enhance any scientific research efforts. Based on the findings of the initial phase of KM implementation - the knowledge audit, framework and partial targets are prepared which we consider important and realistic with regard to the improvement of the collaboration among all members. Subsequently, the implementation project is elaborated and implemented. The process of implementing KM into practice is difficult, very broad, and the first results will not show in the near future. Nevertheless, we suppose that the energy invested in the effort to detect and resolve bottlenecks of collaboration and in the effort to implement the idea of KM in scientific research collaboration is the correct investment. Presently, we use this knowledge in the creation of an appropriate collaboratory for the Memory of Slovakia Project which is now near the end of the technological infrastructure deployment phase to be followed by actual collaboration of researchers. We will observe these processes closely and keep being involved in the KM implementation phase in order to avoid any potential critical issues.

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