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An IS for archaeological finds management as a platform for knowledge management

The ArcheoTRAC case

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Abstract

Purpose – The aim of this study is to describe the context, the activity, and the outcome of a project, which led to the creation of ArcheoTRAC, the first information system (IS) designed to run all the daily activities in archaeological finds management, to share information among the different professionals and to support in this way knowledge creation.

Design/methodology/approach – The study focuses on the ArcheoTRAC system and on the project that contributed to its development. Since the authors of this paper have been involved in the project (one of them since its very beginning), an action research paradigm has been used to derive scientific knowledge out of the experience. Both organizational and technological aspects are investigated under the respective theoretical knowledge management perspectives.

Findings – There were two effective choices in order to foster knowledge sharing in a context of a scarcity of interactions among professionals involved. Grouping representatives of possible users in the project contributed to create a mutual understanding of their interdependent and complementary needs and activities. Moreover, some system features of the ArcheoTRAC system (views, fields and thesauri customization, non-prescriptive workflows) were effective in letting each user adapt him/herself to the new system.

Practical implications – The study sheds light on the characteristics of a system designed in order to maximize the information exploitation and sharing and, at the same time, to minimize the introduction impact, in a context denoted by manual processes, lack of habit of cooperation, and poor IT literacy.

Originality/value – The study deals with an innovative IS that supports all activities performed by every professional involved in archaeological finds management. The study describes the architecture of this IS that has been designed to minimize impacts on professionals' behaviour and maximize knowledge sharing.

Keywords Archaeology, Knowledge management, Cultural studies, Heritage, Knowledge sharing, Information systems

Paper type Research paper

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1. Introduction

Archaeological finds management encompasses all the activities performed on archaeological finds, from excavation, to restoration, study, and conservation. Each find is not just an object that comes from the past. It may rather be a valuable source of data and information.

Each find, after its discovery, starts a new life cycle composed of several stages: at every stage, much information is produced. This information can contribute to increase the stock of knowledge on the specific find, on finds related to it, and more generally, on the specific period of the human history the find belongs to.

To fully exploit the informative potential embedded in archaeological finds, knowledge management practices and, if possible, a supporting information system (IS) could help. Anyhow, observations from reality suggest that organizational routines in place in finds management in archaeology do not adopt optimized knowledge management practices, nor is any IS specifically available to support them (Watrall and Siarto, 2007).

In this descriptive case study we analyse the activity and the outcome of the project named "giSAD – *Recouvrement du Potentiel Informatif des Sites Archéologiques Démontés*" ("Potential Information Retrieval of Archaeological Mobile Sites"), by means of which the first IS supporting daily operations of all professionals working in archaeological finds management, ArcheoTRAC (Archaeological Heritage Tracking, Recovery, Assessment and Conservation), has been designed and developed.

The structure of the paper is as follows. Firstly, some insights on the organizational landscape and on the work practices currently adopted in archaeological finds management is provided, in order to depict some peculiar, not commonly known contexts. Afterwards, the theoretical framework and the design of the research are discussed, followed by the case study description. A discussion on the findings and some conclusions will follow.

2. Information and knowledge management in archaeology

How to manage knowledge in the archaeological field is not a new issue: many scholars have dealt with it over the last decades. However, they have mostly addressed the problem of sharing among archaeologists the results of their studies and research, which is a twofold issue: how to make documents and information available, and how to match the interpretation of a find provided by a scholar (following a school of thought) in a study. Gardin, one of the very first to discuss the knowledge management subject in archaeology together with the possible support of information technology (Gardin, 1971), suggested the use of the web and a special hypertext structure for documents in order to solve the first concern (Roux and Gardin, 2004), and the use of a type of logic inference to make interpretation more explicit (Gardin, 2003).

As already stated, such works deal with the management of knowledge resulting from studies performed by archaeologists on finds, which were possibly discovered a long time before, and had already received more changes of status. This paper, which also discusses the role of information technology as a support for knowledge management in archaeology, handles a quite different point of observation. The system discussed here, in fact, has the aim of collecting all the possible information regarding an archaeological find, since the very beginning (its recovery) and from then onwards. By doing so, it targets all the professionals involved in finds management, coming to constitute a platform for knowledge sharing and creation. In order to deepen the relevance of this system, the following paragraphs describe what happens to an archaeological find following its discovery, and how pertinent data are managed in the process.

2.1 The second life of an archaeological find

Once discovered, an archaeological find (both a mobile object, like a jug, and an immobile one, like a site) starts a sort of new "life cycle", throughout which it will come across several events (among them: storage, cleaning, restoration, study, exhibition, grouping or consolidation with other finds…), sometimes repeatedly. Even though people might be forced to think intuitively about archaeological finds as statues, pieces of jewellery, pieces of pottery, or other artworks, the largest part of them is merely formed by small fragments that only in a few cases can be used to rebuild (virtually or physically) an object. Even if these items are usually not suitable to be displayed in museums or exhibitions, they are, as well, valuable sources of information.

Just for its discovery in a certain place, at a certain depth, close to some other objects, each find brings with it a lot of information (about its nature and history), even when it is impossible, at first glance, to interpret its original form or material (e.g. in the case of single or multiple fragments). For example, the discovery of a group of pieces of Etruscan black ceramic in a specific zone in a northern part of Italy at a certain depth, even when it is impossible to identify the object(s) they were originally part of, testifies the existence of some kind of relations between that zone and Etruria in a certain period.

Each event a find may come across (restoration, study, exhibition etc.) generates a lot of additional information. Sometimes such actions change the nature of the find (as, for example, in the case of the consolidation of fragments found in different moments), or the related information (e.g. after a study that details its origin or dating). All the information gathered is useful, and often crucial, in order to deepen the present and future scientific contribution received by the find (Kintigh, 2006), to make each time the best decision about its management, and, in the end, to make sense of its discovery and overall of its expensive conservation.

Despite its fundamental role, information is often not specifically managed in archaeology (Kintigh, 2006; Karmacharya *et al.*, 2008), almost always not filed in digital archives, and then with difficulty transferred (Watrall and Siarto, 2007) to persons not involved in each single event. The problem of the use and sharing of the knowledge potentially brought by an archaeological find is further increased by the presence throughout its life cycle of several professionals (archaeologists, restorers, storekeepers, archivists …), who usually work separately, even when they cross over each other's activity. Things get even more complicated when considering that normally, data collection methodologies vary deeply from one project to another, and that many times data collection in archaeology is still made with paper and pen (Watrall and Siarto, 2007).

All these circumstances make information and knowledge sharing among professionals in archaeology difficult. As a result, after the recovery on a site, and for a long-lasting period (often forever), the object is merely known by the person who collected it. Such an information black-out not only involves the information linked to the historic and scientific perspective, but also even collocation and needs of conservative interventions of the find, with an evident negative reflection on traceability and, at the same time, on management and programming of interventions.

Figure 1 illustrates the typical organizational chart of an archaeological department of a European country. The chart shows that professionals with the same profile may work in different divisions, usually without direct connections. Every Department is

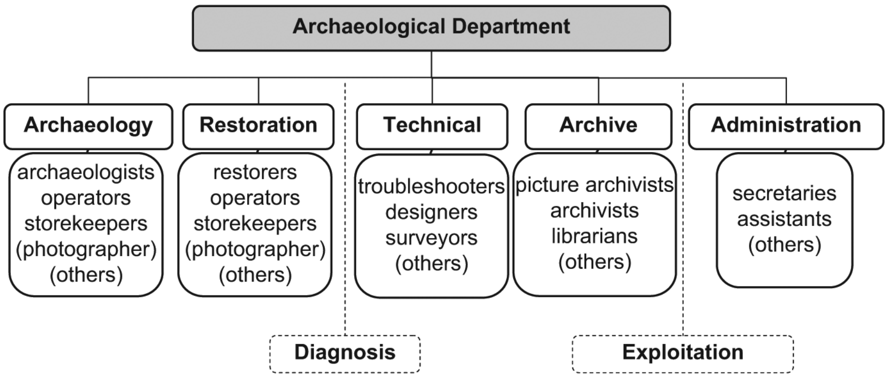


Figure 1. Typical organization chart of an archaeological department

autonomous, has an exclusive territorial competence (in most cases a regional one), and also for this reason, each one can have its own procedures. As a consequence, the processes of finds management (like retrieval, collection, interventions management and others) follow highly diversified procedures, specific for each department, and even for each individual that works on them, also because of the weak relations among different areas. Because of the relevance of culture and personal know-how in this field, very often operations follow non standard practice or context pressure, as in the case of an urgent excavation during works on a railway, when the excavation has to take the shortest time.

Actually, information on finds, when immediately collected, is recorded on many different kinds of supports, such as: single sheets of paper, registers, sides of the wooden/plastic boxes where finds are kept, and so on. In this scenario, the objects maintenance (where archaeologists exit the stage, leaving room for archivists, librarians, restorers, storekeepers and others kinds of professionals) also encounters problems, because of poor information management. In the vast majority of cases, finds are stored in boxes inside depots, and the identification of box contents is based on hand-written data on their sides. In a context where different persons, on many different kinds of supports, have registered information on a find it can be hard to use and connect all these pieces of information in order to properly manage and even identify single objects.

2.2 IS for finds management in archaeology

All these considerations have not to suggest that no IS has been designed in the archaeological field. Since about 1960 a variety of electronic tools have been invented, copied, and adapted, to manage archaeological enterprises and analyse archaeological problems (Voorrips, 1998).

Today different technologies are used during excavation, and also some ISs support them (Karmacharya *et al.*, 2008). Many of them can be classified as a customized and/or extended Geographical Information System (GIS), an important tool in archaeology that can be used to map a site and to document its structure and shape. Combined with adequate supporting systems, GIS can also be used to produce three-dimensional representations of objects or sites. Examples of these systems are 3D MURALE (Cosmas *et al.*, 2001) and DILAS (Wüst *et al.*, 2004).

The adoption and the development of GIS in archaeology had an exceptional development starting from the eighties (Tokmakidis *et al.*, 2004). A GIS simply targets a small subset of data pertinent to archaeological sites and the outcomes of an excavation campaign (in a specific case, spatial data), and therefore can be used to share only a limited proportion of the total informative potential a find might embody. Moreover, GIS data do not span the entire life cycle of archaeological finds, and are mainly addressed to archaeologists.

As examples of ISs that try to overcome the limitations of GIS based systems, OpenArcheo (Fronza *et al.*, 2002), and iAKS (Watrall and Siarto, 2007) can be cited. Even though it contains some information management facilities, OpenArcheo still relies heavily on the GIS functionalities, and it is targeted only to support the work of archaeologists. iAKS instead is proposed as a management system designed to support the main activities of archaeologists and to share information among them. However, the iAKS system is not available so far, its release having only just been announced.

Besides these, the systems devoted to support the "Official Catalogue" must be mentioned. The Catalogue is a tool based on a set of multiple forms, mainly introduced to serve scientific purposes. The Catalogue is usually supervised by a public agency (in Italy, the Cataloguing and Documentation Central Institute, under the Ministry for Cultural Properties and Activities), and contains only the file cards related to the archaeological finds studied, analysed, and moved to the Public Inventory. Each file card reports an ample and structured set of information on many aspects of the find: discovery, material, state of conservation, origin, relevance, connection with other objects, and so on. All these data must be manually filled in and signed by an operator with a high level of competence, usually an archaeologist. Such time-consuming operations can be done only after the find has been involved in some activity (cleaning, restoration . . .), and after an appropriate period of study and research. For all these reasons, only a small proportion of all the finds (about 30 percent) is inserted in the Official Catalogue, however long the time after its discovery.

All the systems mentioned here substantially address only two phases of the archaeologists' work: the geo-localizations of finds, and the post-study documentation of the most important finds. All the other activities related to the finds management are, so far, rarely and only partially supported by an IS. Under these circumstances, information on a find, and on treatments received by it, might be stored on a computer, only because the person in charge of the treatment has keyed it into his/her personal archive. This often happens after a long delay, and personal files have different formats and supports (Watrall and Siarto, 2007). This makes these data difficult to be transferred or interoperated (Lauzikas, 2005).

2.3 Exploiting archaeological finds knowledge potential

In such a scenario, the informative potential of each find (characteristics of the object, characteristics of the site where the object has been found, type of interventions received and so on) can be lost (even forever), or not fully exploited. This makes the recovery and the storage of a scientific "alien" (not known to everyone) and "dumb" (without scientific informative potential) object useless.

The ArcheoTRAC system emerges then as a relevant IS to support all the daily activities performed by professionals working in archaeological finds management, to share information among them and to support in this way knowledge creation. Due to the characteristics of the context where the system had to be employed, denoted by the presence of many different competences, manual processes, lack of habit of cooperation and poor IT-literacy, the system has been designed to be both powerful and simple enough to be adopted by every professional and to support information and data sharing across the entire archaeological finds management life cycle.

3. Theoretical framework

The case of the giSAD project and the ArcheoTRAC system can be studied under several theoretical perspectives. Since knowledge sharing was one of the aims that guided the activities of the giSAD project, and the ArcheoTRAC system has therefore to support knowledge management processes among professionals working in finds management, the theory we decided to apply to analyse the case is that of knowledge management.

From a theoretical point-of-view, knowledge (and thence knowledge management) can be seen in many different ways. There is the objective and subjective knowledge of Popper (1979), the personal knowledge of Polanyi (1962), and the tacit and explicit knowledge introduced by Polanyi and later deepened by Nonaka (1994). The theoretical framework adopted in this paper is based on Polanyi's and Nonaka's works on personal, tacit, and explicit knowledge. We have chosen to adopt their perspective on knowledge since it is a largely agreed theoretical perspective on knowledge, and because the epistemology of their work was much closer to our work compared with that of Popper.

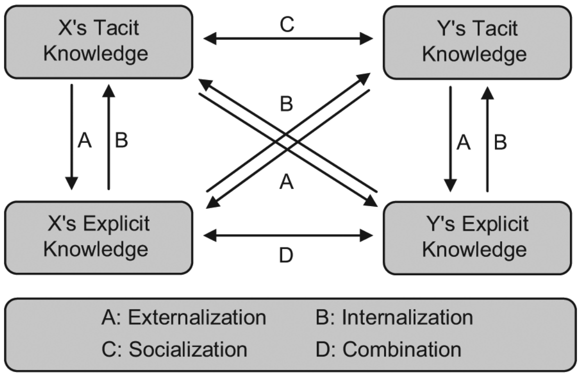
Regarding theory selection, the case of the giSAD project and the ArcheoTRAC IS have two aspects that guided us on the identification of the theoretical framework. First of all there is a human and organizational dimension. In the giSAD project people and organizations cooperated for the development of the ArcheoTRAC IS. By doing so, they have also exchanged knowledge. For this reason, theoretical contributions that give insights on how knowledge is managed among individuals and organizations suit this study. Secondly, this case also takes into consideration ArcheoTRAC, which is an IS that also supports knowledge sharing. For these reasons theoretical contributions describing knowledge management processes supported by ISs are also of help for this study.

3.1 Knowledge management

According to Polanyi (1962, 1967) and Nonaka (1994), knowledge, when viewed in an organizational context, assumes two different forms (tacit and explicit), and involves different processes of transformation from one form to the other (socialization, externalization, internalization, and combination). Figure 2 shows these processes referring to the knowledge exchange between two hypothetical individuals X and Y (Nonaka, 1994; Nonaka and Takeuchi, 1995).

The tacit dimension of knowledge includes both cognitive (the individual's mental models formed by mental maps, beliefs, paradigms and viewpoints) and technical elements (concrete know-how to be applied to a specific context) (Alavi and Leidner, 2001). The explicit dimension of knowledge, instead, can be codified in symbolic form and/or natural language and then communicated (Alavi and Leidner, 2001).

Moreover knowledge can be individual or collective (Nonaka, 1994): individual knowledge is created, and exists in only one person, while collective knowledge is



Source: Adapted from Alavi and Leidner (2001), based on Nonaka (1994)

Figure 2.
Knowledge creation processes

created by the collective actions of social groups. In an organizational perspective, knowledge is also referred to as memory and assumes two different forms: semantic and episodic (El Sawy *et al.*, 1996; Stein and Zwass, 1995). The semantic memory is linked to explicit and articulated knowledge inside the organization (embodied, for example, in reports and archives), while the episodic memory is linked to specific circumstances and their related decisions, actions or outcomes.

Usually knowledge is derived from one or more pieces of information, which are formed by one or more data (Laudon and Laudon, 2006). Adopting a different point of view, Tuomi (1999) affirms that the data/information/knowledge hierarchy can be reversed, since a certain stock of knowledge must exist in the mind of the knower before information and data can be identified or measured. As a matter of fact "raw" data do not exist: each piece of data is the result of a knowledge flow that influenced its identification. As a consequence, a pre-requisite for establishing a knowledge exchange among individuals is the sharing of a certain knowledge base (Tuomi, 1999).

To be effective, knowledge transfers need to take place in a particular context. To describe such a context, Nonaka and Konno (1998) introduce the concept of *Ba* to indicate a shared space where knowledge creation processes may take place, and describe the *Ba* as a foundation for knowledge creation. According to Nonaka and Konno (1998) there might be four different types of *Ba*: Originating *Ba*, Interacting *Ba*, Exercising *Ba* and Cyber *Ba*. Each form of *Ba* supports one of the knowledge management processes.

3.2 Knowledge and IS

Seen under the data/information perspective, knowledge does not present particular challenges for ISs, since it is not so different from data or information (Fahey and Prusak, 1998). ISs can support knowledge sharing providing help in acquiring, storing, distributing and applying knowledge, as well as in supporting processes for creating new knowledge, and integrating it into the organization (Laudon and Laudon, 2006). Computer-based ISs with storage and retrieval technologies can contribute then to enhance organizational memory (Alavi and Leidner, 2001). These ISs are required to deal both with the explicit and the tacit dimension of knowledge: therefore they have to work with unstructured sources of information.

ISs working with knowledge, to be useful, have to connect people and support knowledge exchanges among them. Therefore, besides being only knowledge-oriented, they also have to inherit technical characteristics from other specific systems like business intelligence, collaboration, distributed learning, knowledge discovery, knowledge mapping and opportunity generation (Sher and Lee, 2004). To enhance knowledge sharing among people and organizations, ISs supporting knowledge-based processes have to be guided by an understanding of the nature and types of the organizational knowledge (Alavi and Leidner, 2001). The explicit dimension of the knowledge presents minor challenges for implementation of ISs. It is therefore common to focus primarily on it in an implementation process (Alavi and Leidner, 2001).

Under an organizational perspective computer-based ISs promise to increase and enhance the effectiveness of organizational knowledge by embedding knowledge into organizational routines (Alavi and Leidner, 2001). In spite of the great interest and attention devoted to the application of technology in knowledge management processes, it has been noticed that technology, by itself, does not offer a proper solution to the problem. There might be some barriers hindering effectiveness of ISs applied to knowledge management processes. First of all, knowledge management processes supported by computers are frequently impeded inside organizations by the weakness of the systems in use, and by the ignorance of the *loci* where knowledge is stored inside them (Alavi and Leidner, 2001). Second, the impact of such systems on people's behaviours and routines might also prevent organizations from fully exploiting their capabilities (Chua, 2004). In general, every information system possesses some structural features that have to be aligned with organizational structures in order for the system to have a successful path of usage (DeSanctis and Poole, 1994).

As a matter of fact, the real effectiveness of these systems is disputable (Shin, 2004) and needs to be evaluated case by case. On the one hand, these systems have to manage a blurred and multi-faceted object (the knowledge). The IS has then to be designed to take this aspect into consideration. On the other hand, users need to be freed from any constraints, to have the possibility to make their own links, and to have available the required techniques for constructing and interacting with knowledge inside these systems (Walsham, 2001).

4. Research design and methodology

The ArcheoTRAC IS and the giSAD project compose the unit of analysis addressed in this paper where such a system has been developed. When studying this unit of analysis, the authors of this paper have had a privileged point of observation. One of the two authors has been involved in project activities since the very beginning. He joined all project meetings and played an active role in the project. He contributed to the writing of the preliminary project, helped in its management, and followed the design and development of the ArcheoTRAC system. Both authors had direct access to all the project minutes of meetings and all the project documentation.

Being actively involved in the project activities, a participatory action research paradigm (Wadsworth, 1998) has been adopted for this study. According to Jönsson (1991), and to Baskerville and Myers (2004), in action research projects researchers cooperate with domain experts to identify solutions to practical problems, extending, at the same time, their scientific knowledge. This pragmatic orientation is seen to be a good active approach that best suits IS studies in real contexts (Avison *et al.*, 2001).

This is very close to the case study investigated in this paper, where at least one author had constant interaction with project members during all project activities.

According to the theoretical framework adopted for this study, the analysis of the giSAD and of the ArcheoTRAC IS is made with the aim of answering the following study question:

RQ1. How can knowledge-sharing processes be fostered and reinforced in finds management in archaeology, given the context described in the introduction?

Theories on knowledge management inform that knowledge sharing is both a matter of people involved in it, of loci where such sharing takes place, and of the characteristics of ISs available to support such knowledge-sharing processes. Thence, the research question is articulated in the following propositions:

P1. The role of actors working in finds management in archaeology, given the context described, shall be investigated.

P2. The spaces where knowledge management processes happen in finds management in archaeology, given the context described, shall be investigated.

P3. The (eventual) role of ISs in support of finds management in archaeology, given the context described, shall be investigated.

P4. The structure of ISs adopted in finds management in archaeology, given the context described, shall be investigated.

5. Case description

The Italian autonomous Region Valle d'Aosta, by means of its Co-financed Projects and Research Direction under the Monuments Department, after a long pilot experience, promoted in 2003 an ambitious project, named giSAD, co-financed by the European Union. A partnership was established with other regional Monuments Departments, both Italian and European (from France, Portugal and Spain). Even though each partner's context was different (for rules, practices, resources, size of the territory, number of finds managed), they all operated in the same field (the archaeological heritage management), facing a scenario similar to the one described at the beginning of this paper.

Their common aims were then to define an integrated, shareable and transversal operative methodology and to create on such basis an interdisciplinary IS, capable of supporting everyday activities related to finds management (such as: recovery, documentation, depots management, storage and valorisation).

The multiple objectives addressed with this project can be classified in three dimensions:

(1) *Strategic*, with regard to:
   - the exploitation of the huge amount of finds not studied, through the recovery and sharing of their informational potential; and
   - the opportunity of improving resources use, by estimating interventions cost and by planning interventions on the basis of their possible information contribution;

(2) *Organizational*, referred to the achieving of higher finds protection, improved management, reduced costs, and overall, of a greater collaboration and involvement of all the professionals.

(3) *Scientific*, in terms of research progresses achievable through the availability of much more information, based on more trustworthy data, and a greater exchange of knowledge among diverse disciplines.

Another ambitious goal was the creation of conditions for the implementation of innovative policies in finds management, up to the re-burying of those finds whose informational potential has been totally "extracted" and acquired in a reliable system.

The choice of involving other (even foreign) partners, was explicitly made to raise the expectations and the possible results of the project, on the basis of the thought that in this domain practices and knowledge were (and still are) individual, or however not largely shared. Therefore, the greater the experience involved and the number of needs considered, the more effective the know-how acquired and the operational methodology defined, thus increasing the organizational memory stock (El Sawy *et al.*, 1996; Stein and Zwass, 1995).

Another important choice of the project was the involvement of all professionals – archaeologists, restorers, archivists – who act all along the life cycle of the finds. The aim of such choice was to promote knowledge and needs exchange, as these subjects often operate without a close connection among them, even when they work around the same object.

The project was designed involving a first long phase devoted to declare, and to analyse the practices adopted by each type of professional. The intent was to find a common methodology that could, at the same time, suit everyone's culture, and be applicable to everybody. Moreover, this phase included sessions devoted to search for a possible way to retrieve, store, and share information among different professionals, with the aim of identifying the most feasible way to anticipate data collection, in order to avoid multiple keying and to exclude the risk of losing data.

All the possible situations were examined, including every kind of find (either mobile objects or sites), any event they may come across, and also the treatment of the huge amount of finds actually stored in the depots, even when many of the respective data could already be lost. In 2005, once the preliminary activity of study and design was over, the development of an archaeological and documental heritage management support system (with the name of ArcheoTRAC) was launched. Having in mind the project goals, and taking into account the knowledge acquired in the previous phase, the system was designed in order to maximize users' ability to share and interrelate data (respecting the different needs of each professional at the same time), and to guarantee the traceability of each object in any situation (Pedeli, 2008).

The system presents some interesting features: it is a totally web-based Open Source licensed system, and it largely uses advanced technologies, like HSDPA connections, UHF RFId tags, handhelds, accesses control, and so on. However, there are three characteristics that are of interest for the scope of this study: interdisciplinary collaboration, adaptability to different needs and cultures, knowledge maps of a find.

Regarding the first aspect, ArcheoTRAC lets all the professionals use the same IS and share the same database (see Figure 3): thence a continued interdisciplinary co-operation is promoted among experts in different branches of learning. In this way,

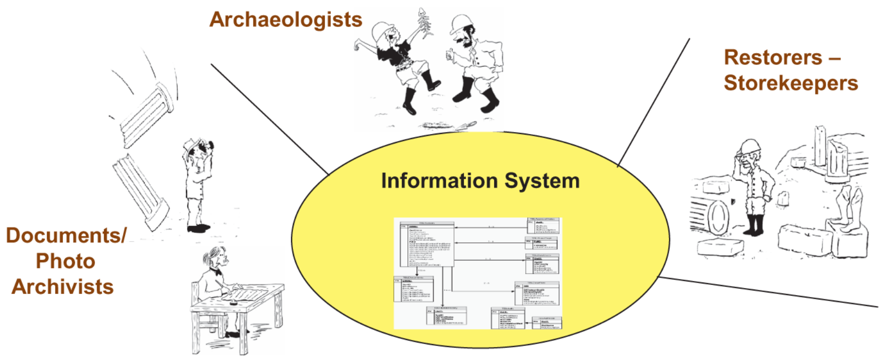


Figure 3.
Different views for every professional, although sharing the same data

they can share the common knowledge base that, according to Tuomi (1999), is necessary to activate knowledge transfers.

With regard to the second aspect, any professional has the possibility of adapting the system on the basis of his/her needs and culture, by:

- Choosing (see Figure 3) the presentation form (view) that better suits his/her needs and preferences (Walsham, 2001), as it contains only the relevant information for him/herself.
- Including in the system (then in the database and the views) other non-standard pieces of information which only he/she will store and read, because he/she is used to collecting and making use of them (for personal culture or practice). This solution then minimizes a possible barrier that may prevent the use of KMS (Chua, 2004).

Finally, by recording all the events of any sort (even when repeated), ArcheoTRAC can trace the entire history of each object after its discovery. It can therefore build two kinds of maps, which give a great contribution both to the research and the management:

(1) a timeline for each find (see Figure 4, where finds are identified by a code), reporting all the treatments, the movements, and other scientific activities concerning it; and

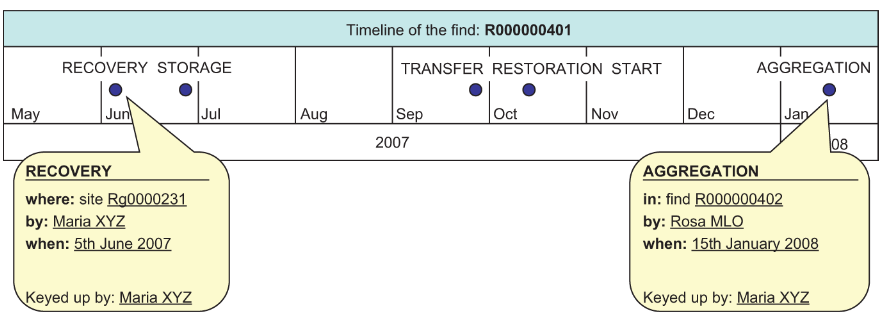


Figure 4.
Timeline of the events in the life cycle of a find

(2) a network of relationships of a find with others (see Figure 5), that shows its active connections, both deriving from a scientific activity ("Concerning") or by a restoration action ("Aggregated in").

This sort of map, as well as many forms, links data on the same object, possibly inserted by different persons. Different interpretations (if any) embedded in the shown data can then be directly compared and mixed up, contributing in this way to increase the knowledge on such object.

At the beginning of 2008, the development of ArcheoTRAC ended and the same team that has been involved all along the entire project started an experimental programme to validate the system against the requirements. The pilot has been performed with selected users of the main partner (the Region Valle d'Aosta). As a result, users asked for some changes to further customize the views in the system. At the same time we have been able to observe that the first users started to use ArcheoTRAC in a short time, and expressed quite positive judgements regarding their experience with it, since they noticed some speeding up in their work.

However, things in archaeology run at a very slow speed. Due to a lack of human resources, the full implementation of the system experienced a delay. Another important partner (the Monumental Department of Rome) started a larger pilot more than one year ago, but it was paused after few months (only end users' training and system set-up were completed by that time), because of a change in leading management.

6. Discussion on findings

In this section we discuss the case described in the previous paragraphs under the light of the study question, and the theoretical framework that have been described previously in the text.

First of all, if we look at the context where the giSAD project took place with the knowledge management perspective, we can argue that the organizational settings were not committed to an efficient management of the knowledge gathered from finds. The absence of linkages among actors, and the diversity in routines among organizations involved in finds management were not in the right position to foster the

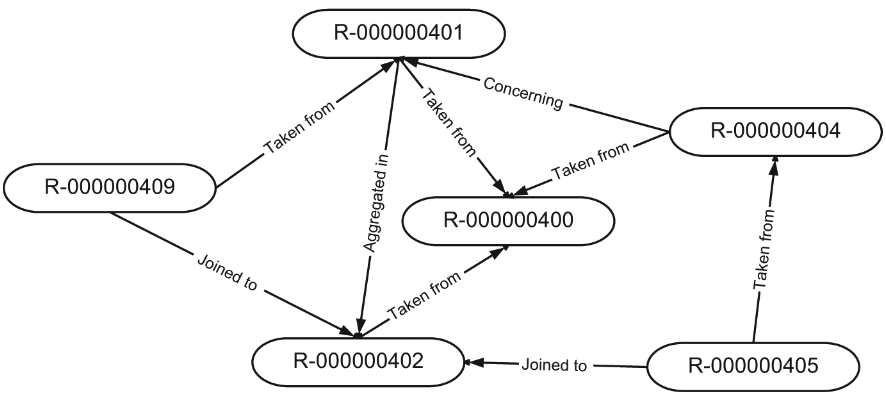


Figure 5.
Relation network among single finds

explicit and semantic nature of knowledge. The giSAD project contributed in this light to inject changes into this landscape.

At first we would like to discuss our *P1* (the role of actors involved in knowledge processes), and *P2* (the role of spaces where knowledge processes take place) together. Referring to the knowledge taxonomy and the knowledge transformation processes described, respectively, by Polanyi (1962, 1967) and Nonaka (1994), professionals involved in daily organizational routines in archaeology have a small opportunity of sharing their knowledge with others without being involved in a face-to-face interaction. All the other forms of knowledge sharing, by means of knowledge representations of some sort (documents, data pertinent to finds filed in digital archives ...) suffer from the described lack of harmonization. The case is even worse for professionals working on different stages of the find life cycle. Since their work on finds is normally situated in two different points of time (i.e. the restoration normally happens after the excavation), they might have no opportunity of being in contact at all.

When professionals meet each other, they can start the knowledge transformation process called socialization by Nonaka (1994), in the context of an Originating *Ba* (Nonaka and Konno, 1998). The Originating *Ba* is the place where individuals share feelings, emotions, experiences, and mental models. This process constitutes the primary form of knowledge creation where socialization processes happen in a face-to-face context (Nonaka and Konno, 1998). This process, even if it is the foundation of knowledge transformation processes, in the described scenario, previous to the giSAD project, was not exhaustive (not spanning the entire organization and the entire life cycle management process).

Under this perspective the giSAD project had the major merit of pushing knowledge-creation processes and knowledge spaces a bit further, putting a representative of all professionals working on finds around the same table, where they had the chance to discuss their needs and to better know each other's activities and their intersections. The giSAD project constitutes therefore a different form of *Ba*, an Interacting *Ba*, which is a more consciously constructed space compared to the Originating *Ba* (Nonaka and Konno, 1998). In an Interacting *Ba*, different persons (with a mixture of specific knowledge and capabilities) in a group, converse and share mental models, but also reflect on and analyse their own. By doing so they enable knowledge to be made explicit by means of externalization processes (Nonaka and Konno, 1998) that contribute to create meanings and values that are shared and agreed in the whole organization. The giSAD project was therefore able to provide the pre-requisites for the promotion and/or the reinforcement of knowledge transfer processes (Gupta and Govinjarajan, 2000), nurturing a rich soil on which making knowledge explicit among involved individuals could take place. At the same time, it helped in the sharing, among different professionals, of that specific amount of knowledge (Tuomi, 1999) that is necessary to start knowledge transfer processes.

Moving on, we would like to add now our P3 (the role of technology in knowledge management processes) to the discussion. The case description discusses the role and the importance of the ArcheoTRAC system, the result of the joint discourse among professionals that happened in the giSAD project. By itself, the ArcheoTRAC system assumes the role of a virtual space in which actors can store and share their knowledge, that is to say, a Cyber *Ba*. In a Cyber *Ba* actors combine new explicit knowledge with existing information and knowledge, systematizing explicit knowledge throughout the organization (Nonaka and Konno, 1998). The ArcheoTRAC system constitutes therefore a further space where knowledge transformation processes in finds management can take place. ArcheoTRAC also supports the transformation of episodic knowledge to semantic ones (El Sawy *et al.*, 1996; Stein and Zwass, 1995) since knowledge stored in the system can easily be accessed also by new professionals who, starting to work on a specific find, use ArcheoTRAC to rebuild its life cycle and to get information on it, even when they had not played a specific role in previous find history.

Finally, the ArcheoTRAC system also offers each actor his own space inside which he/she can work seeing data and information on finds in a way compatible with his/her perspective and culture (Walsham, 2001). This is mainly made possible due to its specific structure (*P4*) that has been designed in the project. Under this perspective, its key features, according to us, are the extensive customization opportunities that try to minimize adoption barriers (Chua, 2004). These features are the following:

- a common database with a minimal set of information needed by each type of professional;
- a workflow decomposed into segments of activities that can be freely recomposed by users; and
- customizable views, fields, and thesauri.

7. Conclusions

This study discusses the role of the first IS that supports daily operations in archaeology of all the professionals working on finds management. There are three elements of understanding gained in this study, which can be generalized.

The first element regards the methodology adopted for this study. We have observed that the participatory action research approach worked quite well in the interchange between the developer side and the research side. Thanks to this approach, it was possible to involve all relevant figures in the development of the system and, at the same time, it was possible to mutually integrate necessary (and sometimes complementary) competences of researchers, domain actors, and system developers.

Moreover, the specific design of the ArcheoTRAC system has been possible thanks to the precedence of the giSAD project. As already discussed, the involvement in the project activities of all the professionals the system would have targeted, helped to share among them the necessary knowledge base. This enabled the definition of system requirements valid for everyone, and at the same time coherent. We can therefore affirm that, when developing a knowledge-related IS, an organization of the design activities similar to the one described in this paper could contribute in generating the necessary pre-conditions for effective knowledge transfers.

Finally, when addressing knowledge-related aspects, particularly in a multi-disciplinary context, the system also has to be designed to meet every user culture or need, without imposing rules, workflows, or (as much as possible) data formats. This consideration however needs further sound proof, as the system usage (the experimental programme started by the Region Valle d'Aosta) that has been observed during this study is quite limited. This conclusion might then be revised when the large-scale implementation of the ArcheoTRAC system is over.

As future research, to deepen the understanding gained regarding the involvement of users, domain experts, and researchers, we are now investigating the dynamics of the interplay among these subjects. Furthermore, we are planning to perform a post-adoption study, as the system will have undergone a large-scale implementation, to eventually revise or extend the considerations here formulated.

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