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USER CENTERED CARTOGRAPHY – PREPARATIONS FOR UBIQUITOUS CULTURAL ACCESS

The technical progress during the last decades knocked down several borders in the context of efficient knowledge communication and spatially related information transfer. Some of these new technical possibilities result in a focus on pervasive and user-centered cartography, which may form a central toolbox for accessing cultural knowledge in a ubiquitous manner.

This contribution discusses information management for cultural tasks, considers general aspects of knowledge acquisition and communication concepts that are relevant for cartographic presentations, shows some evaluation on user behavior and mental maps and tries to classify users by their learn-types.

This work aims at preparing a ubiquitous cultural access with the help of the cartographic methods. Therefore influencing parameters on the cartographic communication process should be identified and used for a more efficient knowledge transmission.

Keywords: cartography, multimedia, ubiquitous, cultural heritage, cognition.

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1. Introduction

The technical progress during the last decades knocked down several borders in the context of efficient knowledge communication and spatially related information transfer. Some of these new technical possibilities result in pervasive and user-centered cartography, which may form a central toolbox for accessing cultural knowledge in a ubiquitous manner.

Production processes for printed maps have been changed and useful media for digital maps evolved. In general digital media empower the distribution of maps to a wide public without nearly any time-loss caused in the production processes. But by following these technical realities one question occurs: What is the main task and use of cartography? Considering the potential of the new media with the usage of multimedia, the main task of cartography may be defined by transmitting information of spatially related data (Gartner 2002). If interaction and thus the possibility to accept reactions of the user within a map is a basic component of the definition of multimedia cartography (Dransch 2002), this task may be extended to the process of "GEO-communication". Considering these approaches cartography is not only a technical possibility to combine and visualise geographically referenced data and objects, but also the communication and effective transmission of spatially related data and combined knowledge. Therefore methods for the useful application of different media and appropriate use of transmission-modes within the cartographic communication process are one main aspect in research on ubiquitous cartography.

The focus on cartographic communication and its presentation forms requires some kind of user modelling, classification and understanding of cognitive processes. It is not the developers view on technical implementation, but the users way of understanding, perceiving and processing knowledge that is responsible for the structure, functionality and user interface of an application. Clear and understandable functions may lead to an easy information extraction, whereas confusing procedures would result in a wrong, missing or misunderstood answer of the system. The importance of users´ behaviour for the development of functionality, design, information presentation or user interface of a cartographic information system causes a strong concentration on the user that may be called user-centered cartography.

The approaches and results of user-centered cartography are very important for the usage of spatially related information communication with the help of small graphic interfaces. The size and resolution of this equipment is very restricted for this kind of knowledge transfer. Thus it seems useful to enable multimedia, like multi-coding (graphic, sound, ...), multitasking and interaction, for the information transfer to overcome restrictions.

A ubiquitous access of different information services becomes enabled with the completion of the personal mobile infrastructure by development of wireless data connections (Bluetooth, WLAN, GPRS, ...). Spatially related information is then spread via "Location Based Services", which could be in the form of tour guides, address finders navigation tools and other information services. Often cultural themes are also location based and may be made accessible with the same tools and services. To prepare this ubiquitous cultural access some reflections on cultural information management, spatial communication concepts, presentation methods and learn-types for knowledge transmission should be made.

The remainder of this contribution is organized as follows: Information management for cultural tasks is briefly discussed in the first chapter. The second part considers general aspects of knowledge acquisition and communication concepts that are relevant for cartographic presentations. Chapter three presents actual studies of cartographic communication techniques in a pragmatic context that should support spatial communication theory by evaluating user behavior and mental maps. A possible solution for the resulting requirement of user classification is described in chapter four by segmenting various classes of learn types and cognitive styles. This work should clarify further steps for a ubiquitous cultural access with the help of cartographic methods.

2. Information management for a ubiquitous cultural access

Cultural information is in most cases spatially related. Depending on movable or fixed artefacts, these objects do have some point of origin, area of trade (where it was traded), area of use (where it was used) or region of influence (where the art or artist was influenced). It can easily be seen that it is important to establish clear definitions for describing this spatial relation.

The spatial relationship of cultural objects is the most important common basis enabling an exploration and information extraction within different knowledge databases. Due to the variety of disciplines that deal with cultural heritage issues, there is an increasing number of highly specialised and individually structured data resources. According to the demand on decentralised cultural heritage information systems, the integration of existing systems is planed and requirements are prepared by several working groups (LUPA 2005). A potential solution would be the creation of a gazetteer or meta-database, because their internal structure may be used within the cartographic information interface. By means of localisation ability relations between the results of neighbouring or complimentary disciplines can be made clear. The gazetteer forms the core of an application for the exploration of highly heterogeneous material objects in their relevance to space and time (for the advantages of dynamic maps with timelines see ECAI05). Thus a form of 'interdisciplinary on-the-fly' can be created with all the additional benefits provided by advanced cartographic visualization tools.

Beside some geographic base data, which are responsible for overall background information and for the spatial context, cultural facts and archaeological data have to be merged (in order to achieve a unified description of spatial relation or distinguishable symbolics in cartographic presentation) and placed on the planet's surface with a geographical reference.

The main challenge in geographic data politics is to create a consistent data structure to enable data combination and usage of this data basis in a cartographic production flow. The demands on quality description and legal issues are very high in order to create consistent map products and a user-accepted interface for data extraction. (Gissing 2003, FGDC 2004).

Once the problems of unifying and describing spatial references are overcome, the next aim is to open the knowledge collection to the public. A ubiquitous cartographic information portal seems to be an appropriate way because of the possibility to spatially structure complex (time and space related) cultural information.

3. Cartography, knowledge and general communication concepts

Spatial structuring of information according to individual organisational and systematic structures supports knowledge acquisition (Zimbardo 1995). In general this structuring works with similarities, size, appearance and temporal behavior, which can also be adapted to information coding in cartography, where semantic classification and hierarchical structuring is used (Buziek 2000).

Direct and indirect experience, which is acquired by imitation and following valuation of imitation sequences, is the basis for creation of knowledge (Bandura 1987). It is a theory of learning roots back to the theory of double encoding, which says that strengthening is evoked by the usage of different modes (e.g. color and sound) for the same information. These processes of motivation and strengthening initiate the creation of schemata and the acquisition of specific behaviors (Dransch 1997). By enabling multimedia in cartography these aspects of double encoding can be taken into account.

Perception and knowledge creation are continuous activities that may be shown in a cycle of perception (Neisser 1996). With the help of individual structures in memory, variable knowledge of the environment is produced, saved and put to schemata by personal experiences. Further impressions, interactions and situations change existing knowledge and individually form and manifest the resulting knowledge.

Preceding theories and thoughts point out that the perception of information is an individual process that is formed by interest, motivation, experience and knowledge. Interactive and dynamic presentation forms are able to assist the transmission of spatially related content because individual habits of perception are supported. Consequently multimedia components and 3D in cartographic applications may enable habitual environments and habits of perception for the user – assuming an adequate interface between the human and the computer. Cartographic examples can be found in papers by Buziek and Döllner (Buziek & Döllner 1999).

The creation of habitual environments and double encoding to support the structuring of information seem to be powerful tools for knowledge transmission, but the cognitive processing of information in the mind of the user needs some time and the danger of preventing the user from grouping the information, creating some schemata and thus adapting knowledge, because of stimulus overflow (Kluwe & Schulze 1994) remains. The symbolisation of selected information, simplification of (virtual) reality and mobilisation of extreme stimuli is essential for guiding and modelling perception in a more efficient way. These elements of perception (e.g. the size of graphical variables) are dependant on the technical characteristics and possibilities of the user interface and the quality of the cartographic modelling procedure that follows these parameters of the user interface.

The creation of knowledge and the definition of a common basis is essential for the communication between two systems (or humans).

Based on the assumption that information and knowledge cannot be copied from one system to another, but is only valid in its own system, communication will only be enabled if the knowledge basis of the systems overlap. This idea of theoretical system approach may be depicted as "islands" (Birkenbiehl 2003). If the islands overlap, two systems are able to communicate. Truth is, what forms the content of the own island. Thus the truth of a presentation or application is what the user defines to be true.

In the case of cartography and spatially related content the knowledge of a user about an environment may be measured by the mental representation or "cognitive map". In a more detailed definition by Golledge, cognitive mapping "implies deliberate and motivated encoding of environmental information so that it can be used to determine where one is at any moment, where specific encoded objects are in surrounding space, how to get from one place to another or how to communicate spatial knowledge to others." (Golledge 1999)

In order to prepare and develop GEO-communication and cultural knowledge access on small pervasive devices the creation of mental maps on the user-side according to cartographic presentation forms needs to be understood. It is the understanding of users' behaviour and cognitive processes that form an important approach in developing a ubiquitous cultural-cartographic information system.

4. Presentation methods and perception of space.

The superiority of the visual (in contrast to the textual) human memory (Dale 1946) causes maps to be claimed as the most important presentation form when communicating spatial information (Däßler 2002, Buziek 1999). Maps can be a good tool to convey an overview of a certain area and related information. They have the advantage of indirectly supporting the user's sense of orientation (Kray et al. 2003). This does not necessarily imply that maps should always be used in each and every situation. People who are familiar with an environment might not need a map at all and are solely looking for route planning advice, and some people have difficulties reading maps and prefer different presentation forms.

Anytime designers create maps, a lot of additional decisions have to be made before the final version of the map emerges. The first question that arises concerns the amount of detail to be displayed on the map in order to avoid information overload and preserve understanding. One possible way to overcome this problem is to create layers and adopt the amount of layers to be displayed to the respective user needs while making sure that all necessary information is included.

Whenever maps are used as navigation aids, an egocentric map view is proven to improve the efficiency of wayfinding tasks among pedestrians (Darken & Peterson 1999; Foltz 1998; Zipf & Jöst 2004). Therefore pedestrian navigation systems should at least offer the possibility to switch between a north-bound and an egocentric map view.

Unfortunately the visualisation of a well-structured map alone, does not guarantee wayfinding success. Humans typically process information better, if double- or triple-encoding is supported (Belke & Rehm 2003; Michon & Denis 2001; Klippel 2003).

Images, video and animation are generally not a good choice of presentation form when trying to give an overview of a region, but they can serve as additional tools for spatial related information of landmarks or sights (Reichl 2003; Radoczky 2003). Images and videos typically require a lot of time when comparing them to reality and animation easily leads to information overload (Robinson 2004; Anglin et al. 2004).

At present 3D presentation forms within cartographic applications do not prevail in the digital wayfinding market, but are often used in cultural heritage information visualization. A possible reason for this could be the technical restrictions that influence usability when testing prototypes. Most applications are rather complicated to handle or demand technical resources that are not always available in the used computer systems. Most commonly VRML models or game engines are offered within the application, but even here the additional display of a 2D map is favoured by candidates who tested the system on a desktop computer (Chewar & McCrickard 2002).

It is possible that augmented reality systems could fully replace conventional navigation systems in future. Before they fit to be commercialised a lot of research needs to be done in aspects of devices, positional accuracy, tracking, usable semantics and semiotics. This innovative technique could possibly be applied to indoor and outdoor environments as well as immersive learning applications.

When combining indoor and outdoor navigation systems two different presentation forms, or in case a map and a floor map are used, at least two different scales have to be combined when switching from one mode to another. This transition should appear to the user as a logical and seamless step. One possible solution to this problem is the technique of "dynamic zooming" that slowly changes the scale and the level of detail of the map until the new indoor floor map evolves when entering the building. Another possibility is to distract the user by showing an image of the entrance or some additional textual information before an indoor floor map suddenly appears on screen (Radoczky 2003).

Even though maps can differ dramatically from the perceived structure of a spatial environment, people instinctively consult maps when they have to find their way through an unfamiliar environment (Iachini and Logie 2003). So far newer techniques like virtual and augmented reality, animation and many other multimedia tools could not replace, but expand cartographic presentations. Their capability of conveying good overviews of areas in question and transmitting knowledge with spatial relation are unrivalled until today (Kray et al 2003). This fact may empower maps to be an appropriate toolbox for accessing cultural content with spatial relation in a ubiquitous context.

4.1. Map influences on mental map generation

In a test case at the Vienna University of Technology, 24 undergraduate students' current mental map of their respective environment was inspected. There is no insight on how they actually gained knowledge about that area. Many possibilities are imaginable when getting into contact with an unknown area, but most likely people first look at a city map when visiting Vienna for the first time. But what did this map actually look like? And how did it influence the composition of their mental map?

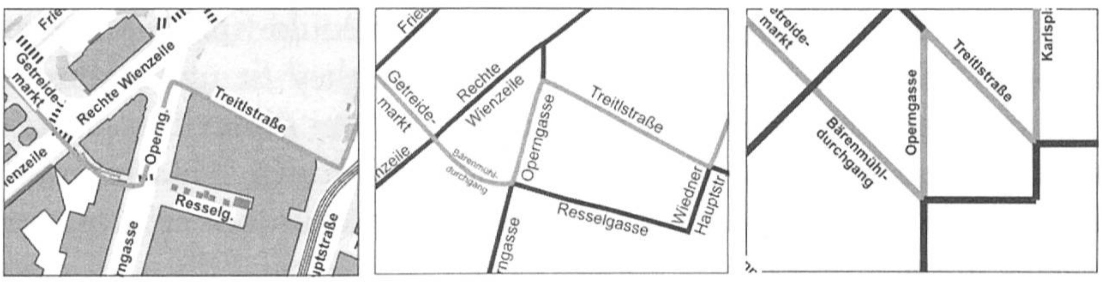

Fig. 1: Different types of maps – topographic map, street graph and schematic map (from left to right), (source Radoczky)

In order to investigate this problem, eight foreigners, who were not familiar with the test area and sixteen residents, who spent a lot of time in that area were asked to participate in a wayfinding test. All of them had to follow the same route. The map source, which was their only guide during the trip, was chosen individually. Three different depictions were provided for the test. Number 1 was a strictly schematic map (see figure1 right), number 2 was a depiction of the street graph (see figure1 middle) and number 3 was a topographic map (see figure1 left).

The schematic map was presumed to be the most challenging navigation aid of all. As a linear cartogram it is designed to convey only essential features of network routes (Monmonier 1996). Linear features are abstracted until only their functions remain (but not necessarily their location) and the map can therefore only serve as a graphic representation of topology (Elroi 1988). Agrawala and Stolte (2001) describe difficulties with schematic maps amongst users, because they provide little detail outside of the main route. Especially if a navigator accidentally strays away from the route he could have difficulties to find his way back. Additionally distances and angles can be highly distorted and lead to confusion. Nevertheless, the test could show that people who are familiar with the test area and who only want to find a certain target do not have any major difficulties with this presentation form once they got used to the unusual depiction. Among the people who had to find their way with the schematic map, only a tourist, who has never been in that area before, had major difficulties to follow the route. The other foreigners, who tested the street graph and the topographic map, stayed on the right track without any problems.

Subsequent to the wayfinding task, test candidates had to draw a sketch of the visited path. As expected the sketches of the local people were quite precise and northbound, even though all of them navigated along the route with the help of the schematic map. The outlines of the foreigners, on the other hand, were all pointing southwards, which was the starting direction. As expected these pictures lacked a lot of information. Figure 2 show the topographic map, which was the information source for one of the tourists (left), and the sketch map of the same person after the test (right). Here we can observe that corners are sometimes rounded and that many different angles are used to visualize intersections.

When looking at figure 3, which were the source and the product of another tourist, we can observe a similar constellation. A lot of detail is missing and the streets are curved.

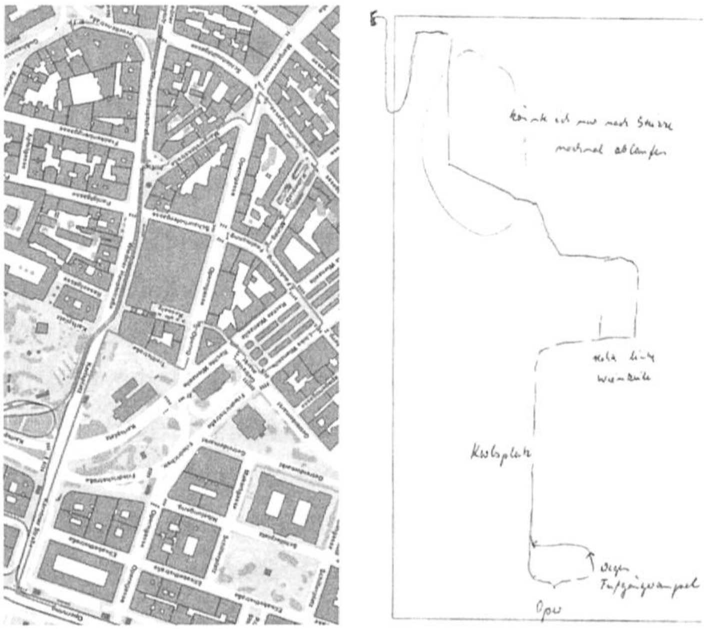

Fig. 2: Topographic map (left) with sketch map (right), (source Radoczky)

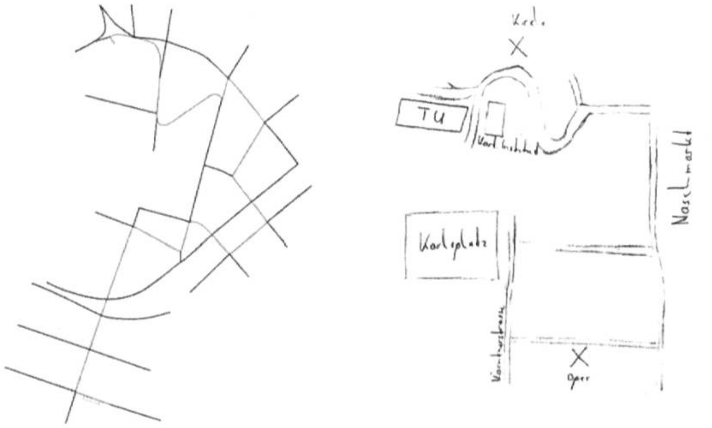

Fig. 3: Street graph (left) with sketch map (right), (source Radoczky)

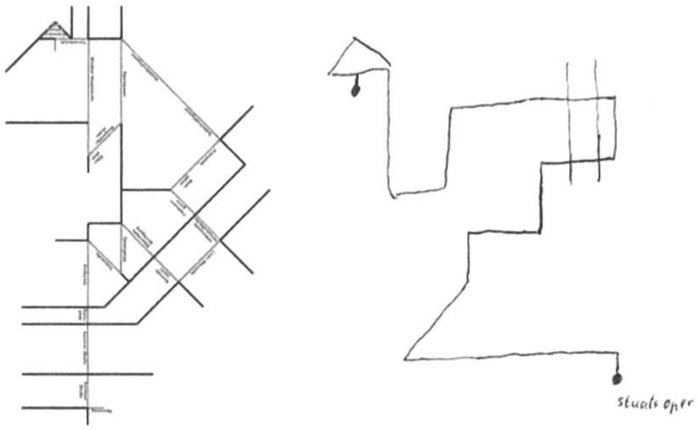

Fig. 4: Schematic map (left) with sketch map (right), (source Radoczky)

One of the most interesting figures is the sketch of the person who used the schematic map (figure 4). Here we can clearly see the influence of the schematic map, which only uses perpendicular or 45° intersections. Even a large distortion of the distance between two intersections (compare figure 4 and figure 3 at the top), was adopted in the sketch.

The wayfinding test could show that the presentation form used when navigating along an unknown route could highly influence the generation of the user's mental picture of the environment. It expresses the importance of the cartographic presentation form and its abstraction, which may result in a topology or geometry based mental map.

This mental map can be seen as the geographic structure and basis for spatial related knowledge acquisition in a cultural-cartographic information system. Such an offer of structure is able to form one potential approach to support individual student needs and to improve memorisational skills in learning aspects (Armani et al. 2002). Because it is not possible to create a public information system with complete individual based functions and applications until now, the classification of user groups, related information extraction methods and different learn-types seem to be helpful. In any case, this classification of the user helps for the first steps in a real user-centered cartographic learning application. The following chapter tries to classify users according to their learn-types and cognitive styles.

5. Learn-types and user classification

The spatially related knowledge structuring that is offered by the cartographic presentation form is supposed to be helpful within learning processes. In general these processes are split up into the "approach to new information and reception", with the collection and organisation of information (Neisser 1996; Jonassen & Grabowski 1993), and "information processing" (Mayer 2000). Both of these steps are related and depend on existing knowledge of the user (Buziek 2000; Heidmann 2002).

An application on educational purpose would have to consider both steps of learning (Brunner-Friedrich 2004), each adapting the user to special groups when focussing on clearly divided extreme values (in nature the user-habit is a mixture of these classes). Concerning the step of "information reception" classes are named "active/passive" (Mayer 2000) and "holist/serialist" (Jonassen & Grabowski 1993; Pask 1976), concerning "information processing" and presentation forms differences in "aural/visual" (Blumstengel 1998; Feichtenberger 2001) and "abstract/graphic oriented" (Dransch 1997; Paivio 1978) are imaginable.

In acquiring new information an active or passive approach is observable. *Active users* search and gather information with the specific aim to work on topics. Questions like "I want to look for a certain village!" or "Which phenomenon can be named at this location?" are representational. *Passive users* want to receive all relevant information by the use of ready-made material within a given lecture. This attitude on the acquisition of new information leads to statements like "Show me the location where this certain phenomenon can be found!" or "Show me further information about this location!". These observed approaches of users call for various operator modi to be implemented in an application (Brunner-Friedrich 2004):

- Research mode needs a high grade of interactivity to explore some information (Figure 5 left). The extraction of information is done by the user in a very active way.
- In lection mode the system provides all steps to go through the information (Figure 5 right). No or very low interactivity is needed to receive information.
- Encyclopaedia mode is a mixture of research and lection mode. The user searches for information parts in an active way and receives requested information by the system with low interactivity. Thus the system serves as a reference book, where the user can search for definitions or explanations.

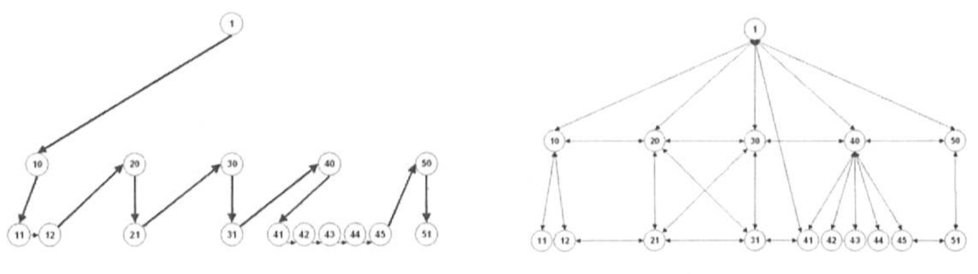

Fig. 5: Passive and active information extraction, (source Brunner-Friedrich 2004)

In addition to this distinction in activity, the user may also be classified by regards of "level of detail" for information extraction – the holist and serialist (Jonassen, Grabowski 1993; Pask 1976). The holist needs an overview before detailed information can be perceived.

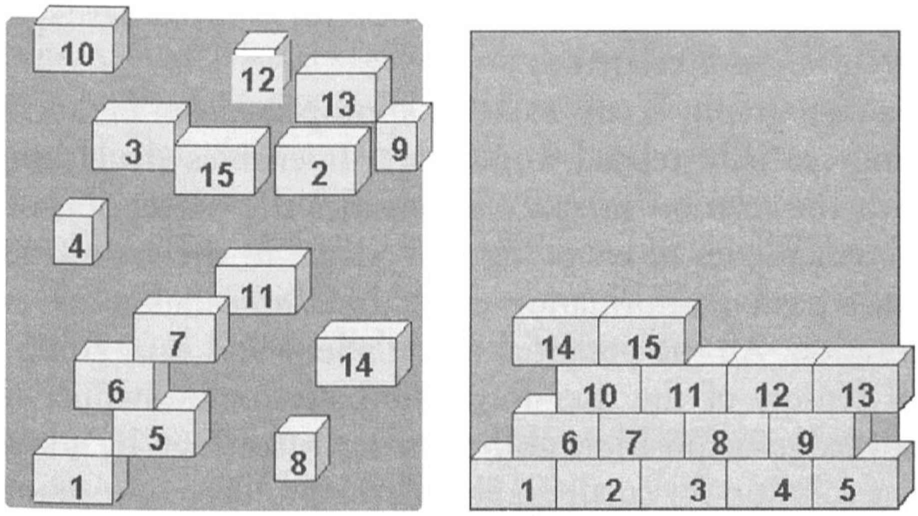

Fig. 6: Holist vs. serialist, (source Atherton 2001)

Based on a summary, the main focus is to extract certain parts of a theme. These steps follow a top-down approach where gaps can arise and detailed information can be neglected (Felder 1993; Jonassen & Grabowski 1993; Pask 1976).

The serialist starts at the beginning with detailed information. This bottom-up method concentrates on details and disregards the correlation between some parts. The general concept is based on a certain sample (Figure 6) (Felder 1993; Jonassen & Grabowski 1993; Pask 1976).

After the collection of information the processing of the data follows. Here distinctions of the user-classes may be made by their preferences concerning presentation methods (aural/visual, abstract/graphic orientation). Some users put information to schemata by aural presentation, whereas others need to read it (visual presentation). These different uses of modes are extended by the level of abstraction of presentation, which opposes for example a map and an aerial view – to depict a very high level of abstraction or no abstraction at all.

As a result of this study a ubiquitous cartographic access to cultural knowledge has to support these various learn-types with appropriate programming techniques in order to offer a successful knowledge transfer for all user classes.

6. Resume on access to cultural knowledge and user centered cartography

A ubiquitous access to cultural knowledge would be an interesting support for the work of historians and archaeologists, education purposes as well as tourist applications. The spreading of this knowledge among various user groups establishes some consciousness for cultural heritage and the region the culture it is related to.

Multimedia cartography seems to be an appropriate tool for accessing and transferring spatially related knowledge. It enables structuring of knowledge with the relation in space, intensifies the perception of the user with different modes of encoding and adapts to the various learn-types with active/passive information extraction and serial/entire information presentation. All the potential modulations and thus going into the individual sensors of the user form the basis for individual mind mapping, knowledge acquisition and spatial structuring. In addition, multimedia is a solution for small graphic devices to overcome graphical restrictions and still offers efficient information transfer to the user. It is the ubiquitous access, used for Location Based Services, that is the reason to solve this problem of small graphical user interfaces.

Some projects in the field of Location Based Services (Lol@, NAVIO) with small devices at the Vienna University of Technology within the Research Group Cartography focused on presentation methods, GEO-communication and alternate methods of information transfer. These first steps in multimedia cartography for GEO-communication, knowledge and cultural information transfer may be seen as preparations for a ubiquitous public cultural access. The hypothesis for further research in this aspect is that cartography with new media may provide a powerful access and structuring of knowledge for cultural information.

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