6 Designing Suitable Cartographic Multimedia Presentations

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6.1 Introduction

For cartography the predominant medium to present spatial information has been the map. Cartographers have developed suitable methods and theories for map construction and map use. New developments like multimedia presentations or mobile mapping, however, go far beyond a single map. They are highly interactive systems where cartographers and map users can envision geographic information using different media, like sound, video or animation, according to their particular purpose and interest. Multimedia cartography, therefore, requires methods and theoretical principles which concern not only the map but also other media.

The recent developments of multimedia techniques offer a wide range of hard- and software equipment that enables cartographers and map users to create and use cartographic multimedia presentations. To apply the powerful technique in a suitable way it is necessary to choose and combine media which best support the purpose of a multimedia presentation. This chapter focuses on two topics which are fundamental for suitable media application and combination: the function of media and the medium as an artefact. The question addressed is: to what purpose should a particular medium be put and what medium best suits this purpose?

6.2 Media functions and media as artefact

The importance of map functions was emphasised by Papay (1973), Ogrissek (1987) and Freitag (1993) because functions determine both the content and design of a map. In cartographic multimedia presentations atten-

tion also needs to be given to the functions that a particular medium has to fulfil, because the function controls the choice of media and how it should be combined with other media.

Functions of media in a cartographic multimedia presentation can be considered from different points of view:

- the function a medium has to fulfil in the perception of information;
- the function a medium has to fulfil in knowledge generation; and
- the function a medium has to fulfil according to the purpose of communication.

The suitability of media to present particular information, for example animations to show processes or diagrams to show relations between values, will not be discussed here as it is widely covered in literature (Schröder 1985; Schnotz 1994; Borchert 1996; Dransch 1997).

A further aspect which determines the choice of media as well as media combination is the task that supported by a multimedia presentation. Media have to be regarded as artefacts which are used to reach a specific goal. For that reason the task and its related activities are of great importance, too, when designing multimedia presentations.

6.3 Functions of media in information perception

A common opinion in the field of multimedia application is that as more media are applied and thus more senses involved, a better presentation results and thus aids the perception of information. This adoption is based on a paper by Dale (1946) where he points out the intensity of information processing according to different forms of information acquisition. A typical breaking up might be hearing causes 20%, seeing 30 %, and hearing and seeing 50% contributing to information acquisition. This ‘summation theory’ was criticised by other researchers (Dwyer 1978; Weidenmann 1995a) and it cannot be naively translated directly to multimedia as acoustic information presentation effects 20%, pictorial information presentation effects 30%, acoustic and pictorial information presentation effects 50% of information acquisition. Multimedia presentations often overwhelm the user as they are constructed according to summation theory and not according to conclusions from perception and cognitive research.

Human perception and cognition are restricted by several constraints (Paivio 1969; Neisser 1974; Kosslyn 1980). In the context of multimedia, particular attention must be given to limited capacity of short-term mem-

ory and the overabundance of single senses. Human short-term memory has the ability to retain only a few information units (four to seven units) simultaneously. In the case of information overload short-term memory information process is insufficient. It has been shown that information processing can be improved if information is repeated or elaborated upon and if perception is directed. Information should also be divided into separate visual and acoustic media to relieve single senses.

Considering this perception view, media may have the following functions in cartographic multimedia presentations:

Function of avoiding an overload of information

Media that have to serve this function must prevent information overload. Information overload can occur especially with dynamic media like cartographic animation and video. Text used as an additional medium can avoid the overabundance of dynamic media because it can name presented information and prepare a user for that information (Lurija 1992). The text should be directed to a second sense organ and be presented in an acoustic form to relieve the visual senses from perceptual overload.

Function of increasing important information

Media which have to emphasise important information must repeat and elaborate a particular piece of information. In cartographic multimedia presentations different media like maps, pictures, text and sound can be combined to show various aspects of a spatial object or phenomenon and, in that way, they can increase and accentuate information.

Function of directing perception

Media that have to fulfil this function must direct perception. They have to guide the users' interest and direct their attention to significant information. Written or spoken text like "compare", "take note of" or "look at first" may help to exploit maps, pictures or cartographic animations.

6.4 Functions of media in knowledge generation

6.4.1 Cognitive approach

According to constructivist theory, knowledge is not objective and cannot be transmitted from one person to another. Knowledge is something very

individual which is generated in a personal cognitive process and depends highly on a person's pre-knowledge and on the form and context of its presentation. Pre-knowledge acts as a filter which directs perception as well as enabling the interpretation of new information (Neisser 1974; Antes and Mann 1984; MacEachren 1991). The more pre-knowledge that exists the more new information is activated, and thus more filters can be brought into use, leading to a more comprehensive knowledge processing activity. Presentation form and context also affect the structure of knowledge (Howard 1983). Different presentations give different insights into a phenomenon. They guide the creation of various schemata or mental models, and in this way they support the generation of multifarious knowledge structures.

Cartographic multimedia presentations should offer a generous palette of various media plus flexible media combinations to support the user. This must be characterised by the users' personal pre-knowledge and competence in comprehensive knowledge generation. This is especially true for cartographic multimedia presentations provided via the Internet because they often lack a defined user group. Media may have the following functions in this context:

Function of activating pre-knowledge

Media that have to activate pre-knowledge must present familiar information. They have to support the organisation of new knowledge in such a way that they offer points of contact from existing knowledge to new information. In cartography maps of strange areas are often combined with maps of familiar regions to allow users comparing the new with the familiar. Another example is sound of a particular time period or spatial area that can associate known and unknown information. Not only maps and sound but all media can fulfil this function.

Function of multiple presentations

Media which have to support multiple presentations must show information in various forms to offer the user different decoding schemata. They should display information in several abstraction levels, in different graphical presentations or in acoustic and visual form. All media are able to contribute to this function.

6.4.2 Approach of Erkenntnis theory

A further contemplation to knowledge creation comes from Erkenntnis theory (Keller 1990). This theory is based on the concept that knowledge creation occurs in a hierarchical sequence in different steps of appreciation: *experience*, the direct observation or action in the real world; *abstraction*, the generalisation of information obtained through experience; and *knowledge transfer to the real world*, the setting of knowledge obtained through abstraction in relation to the real world, for example for prediction or planning.

The concept of Erkenntnis theory was transferred to cartography and related to map construction (in the sense of map modelling) and map use by Sališcev (1975), Berlijant (1979), and Ogrissek (1987). According to this approach maps are differentiated according to their different levels of knowledge generation. First level maps show information obtained by direct observation, second level maps show transformed information and third level maps give recommendations for acting in the real world. This diversification can be also transferred to other media. Pictures or natural sound for example are first level media, maps or animations are second level media and a simulation is a third level medium. According to their levels of knowledge generation, media can support the different steps of appreciation - experience, abstraction and knowledge transfer to the real world.

In the field of computer visualization the idea exists that the more realistic a presentation is, the more helpful it is in information presentation. Therefore much research work has been undertaken to develop methods and techniques for creating more realistic presentations. Realistic presentations, however, are, according to Erkenntnis theory, suitable only for certain levels of knowledge generation. Other levels require a higher level of abstraction. In a cartographic multimedia presentation we have to decide which levels of knowledge generation are for support and which media are suitable to be included to show the information. In this context media may have following functions:

Function of supporting direct observation

Media for direct observation have to act as a substitute for the real world. They have to give a vivid impression of a spatial object or phenomenon. 2D-pictures, 3D-hologramms, video, animation in the form of realistic simulation or virtual realities and natural sound can be applied for that function.

Function of supporting abstraction

Media that have to support abstraction must present information in a processed and transformed way. They must be able to convey general concepts that go beyond individual situations. Maps, abstract animations, diagrams, and formal sound used for data exploration are suitable media in this context.

Function of supporting knowledge transfer to the real world

Media that have to support knowledge transfer to the real world should be able to show the effect of human interaction on the environment. They must be able to integrate existing and conceived objects. Suitable media are maps for prediction, virtual realities for decision making in planning and visual and acoustic simulations. An example of this is the simulation of the noise of planned objects like roads or airports.

6.4.3 Didactic approach

A third aspect in knowledge generation comes from didactic research. Didactic science investigates the processes of teaching and learning. A subdivision in didactic science is the didactic of media that focuses on media applications in the teaching and learning process. Issues of research here are the role of media in instruction and the functions of media in the learning process (Schulmeister 2001, Issing and Klimsa 2002).

Cartographic communication (as a dialogue or a monologue) can be regarded as a learning process in which spatial knowledge is created. Therefore principles of media application developed in the didactic can be transferred to cartographic communication and cartographic multimedia presentations.

Didactic science mentions different functions of media in the learning process (Strittmatter and Mauel 1995; Weidenmann 1995b). Some of these functions are significant for cartographic communication and will be elaborated here. They are the informing functions of demonstration, setting in context and construction, and the directing function of motivation.

Function of demonstration

Media for demonstration should help a user to get a suitable ‘picture’ of a phenomenon. For this task pictures, videos, realistic graphic representations and animations as well as virtual realities are suitable. Audio can give a vivid impression about noise and its spatial distribution. Media for demonstration are particularly useful and necessary for people without great

knowledge about the topic being presented. (This function correlates closely with the function of supporting immediate observation in Erkenntnis theory).

Function of setting in context

Media that have this function should help a user to set information into a greater context. All media that can give a spatial overview or a thematic integration are suitable for this function. Examples are the traditional overview maps that present a wide spatial area, video that shows the neighbourhood of a spatial object or object group, or sound used to present the typical sound of a particular area or time period.

Function of construction

Media with the function of construction should help the user to create complex mental models. Mental models are constructions of pictorial and propositional knowledge about information units and their relationships. Media for this purpose have to inform about concepts, elements and their relationships. The creation of mental models is highly influenced by applied media. Pictures or realistic presentations are not suitable in this context. On the contrary, this function requires abstract media that show prepared information like text, maps, diagrams, graphs, abstract animations or formal sound. Media for this purpose have to initially give an overview of the complete information structure and subsequently they have to inform about detail.

Function of motivation

Media with motivational function should arouse the user's interest and attention. Knowledge acquisition depends highly on a user's motivation. Motivation can be produced by attraction and by moving and changing media. Therefore attractive pictures, dynamic media like animation and video and sound are best suited for this purpose.

6.5 Functions of media according to the purpose of communication

Functions of media (especially of maps) related to the purpose of communication are a particular point of interest in cartography (Board 1967; Papay 1973; Freitag 1993). The function of a map determines its efficiency in a distinct application and it affects its content, its design and its scale. According to Papay (1973) the primary determinant of a map's function are

the users' requirements and interest, their knowledge about the presented subject and their experience in map reading. Later, Freitag (1993) distinguished several functions of maps. In multimedia cartography these functions have to be considered in the context of all available media. The functions are:

Cognitive function

"This function encompasses all processes and operations which generate and enhance spatial knowledge. All processes of ... map analysis, ... transformations, generalisations, animations, etc. should be listed here, if possible in a sequence of operations leading from near reality models to very abstract models of space" (Freitag 1993, p. 4). All media may support this function. Pictures, video, realistic animations like virtual realities or simulations, and natural sound can give a realistic impression of a spatial phenomenon. Maps, abstract animations, and artificial sound are able to present abstract models. The application and combination of different media depends on the users' competence. The higher the competence, the more abstract media can be.

Communication function

"The communication function (including demonstration function) encompasses all processes and operations of spatial knowledge transfer from a map maker to a map user" (Freitag 1993, p. 4). This function can also be performed by all media mentioned in the context of cognitive function. The application of media for communication has to be directed by the users' competence and by the different levels of appreciation distinguished in Erkenntnis theory.

Decision support function

"Decision support function encompasses all processes and operations which -based on evaluation of spatial phenomenon – result in spatial decisions and spatial actions." (Freitag 1993, p.4). Sub functions are navigation, spatial planning and persuasion.

Navigation

Navigation requires media that direct a users' way finding. Route maps or text for example as spoken instruction in a travel pilot may suit this function. Animations in the form of virtual realities and fly- or walkthroughs in combination with landmarks or an overview map might be another possibility. The efficiency of these animated presentations has not investigated comprehensively thus far. Spatial planning demands media that can present existing and conceived objects. Maps, animations, visual

and acoustic simulations and virtual realities are suitable media for this function. Persuasion requires media to present information according to a particular interest on one hand or that touch emotions on the other. Suitable media are maps, pictures, video, animation and sound.

Social function

"Social function encompasses all processes and operations which result not in spatial but in social behaviour and actions" (Freitag 1993, p. 4). Examples are media as cultural or prestigious objects as well as media as tools with social power exercised through the access or denial of access of spatial information. The social function can be performed by all media.

6.6 Media as artefacts

Beside this more cognitive and communication oriented functions of media a further aspect has to be considered when choosing media and media combination in multimedia presentations. It is the task which has to be fulfilled, and the goal that has to be reached. A multimedia presentation is not just an information product it is also an artefact that has to support a person to achieve a certain task (Dransch 2001, 2002). Therefore, a cartographic multimedia presentation also has to be designed according to the requirements of the task. Presently, tasks have become more important in cartography. Recent developments in mobile and ubiquitous computing focus on the context in which a cartographic representation is used; beside location the task is a major component of context. A good basis for this task-oriented approach is Activity Theory which offers a suitable framework to model and characterise tasks (Nardi 1996).

A task can be described by different components:

- a goal which has to be reached;
- a sequence of activities (or actions) that has to be performed to achieve the goal;
- an actor in a certain role; and
- rules that have to be considered during the activity.

For cartographic multimedia presentation all these components are of importance. If cartographic presentations are regarded as artefacts it is necessary to know the activities they should support. In a cartographic context two types of activities exist: activities related to the real world, e.g. navigation, and activities related to the cartographic presentation, e.g. de-

tecting location A and B, and finding the best route between them on a map. Both are connected and must be regarded for choosing useful media. A good overview of real world and map activities is given in Heidmann (1999) and Reichenbacher (2004).

The actor and his/her role also influence multimedia design. The map users and their characteristics like age, culture, interest and knowledge have to be considered as well as aspects of perception and cognition. From the perspective of tasks and artefacts a further point is of interest when describing the user or in this case the actor. Activity theory postulates: "You are what you do". According to this, the activity strongly affects the user/actor and characterises him or her. Bearing this in mind, cartographic multimedia presentations should be designed not only for the information processing user but also for *active users* e.g. "children undertaking learning or 'spatial data explorers' or 'spatial navigators'.

Finally, a task-oriented approach has to deal with the rules that are in operation with a certain task. It has to be proven, if the rules can be shown in the multimedia presentation. For example when planning a gas pipeline the acting person has to conform to different rules, e.g. keeping a minimum distance to another pipeline. The minimum distance could be visualized to support the acting person.

A task and its related activities can be seen as the superior criterion when designing a suitable cartographic multimedia presentation. The activity determines which processes are to support and therefore, which media should be selected and combined. Figure 1 depicts this relationship and gives an overview about the different map functions.

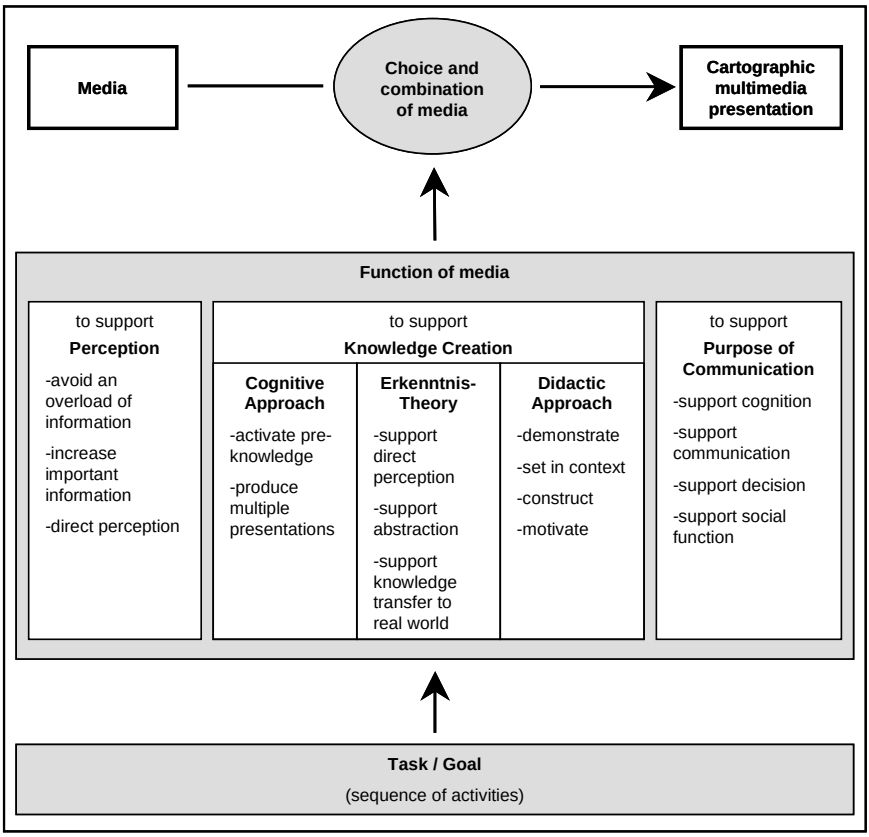

Fig. 1. Task and media function as influencing factors for cartographic multimedia presentations

6.7 Conclusion

The literature of multimedia points out repeatedly that not only the technical dimension of multimedia but also its application dimension needs to be considered. Only the application context accomplishes multimedia *techniques* to real multimedia *systems*. Klimsa (1995) mentions that not any arbitrary combination of media can be labelled as a multimedia system; only the combination of multimedia techniques, application context, and functionality can define actual multimedia systems.

This chapter's discussion of the functions of media and the artefact perspective in cartographic multimedia presentations has been undertaken to contribute to the strengthening of the application dimension of cartographic multimedia presentations. The media functions provided and the task-oriented aspects outlined should help in selecting and combining media in such a way that cartographic multimedia presentations are regarded as more than just a summation of individual media. This approach can contribute a useful application of multimedia to cartography. This is essential if multimedia is used as more than just entertainment and it supports the presentation and exploration of spatial data.

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