TEACHING MAP USE CONCEPTS TO CHILDREN

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1. Introduction: From the landscape to the map and back again

The scheme in figure 1 shows how part of the Real World will be represented, via sequences of invisible and digital models, in visible graphical images. Through observation of our environment we form a mental landscape model. When we want to convey this to others we will plan in our minds how to visualize this. In doing so we will probably use some common notions or conventions and represent the relevant data in the form of a map. Nowadays we can be assisted by a computer which we can feed with digital data about the environment we consider relevant. We can structure the relevant files into a database (digital landscape model) from which, in turn, we will select data and transform them into a digital cartographic model, and visualize this through the use of a graphical processing language such as Postscript.

The scheme also shows how we go back from maps and form ideas about parts of the real world from them: we observe them and process these observations by opposing or confronting them with the mental landscape models we already have, integrating them if possible. The purpose of these actions is to allow us to interact with the Real World. It is this route and the concepts needed to travel along it, that are the theme of this paper (this scheme is based on the work of a Dutch map use and interaction consultant, Van der Schans (1995). I will use his scheme as a framework for looking into the current research on map use skills and on the concepts involved, in the Netherlands).

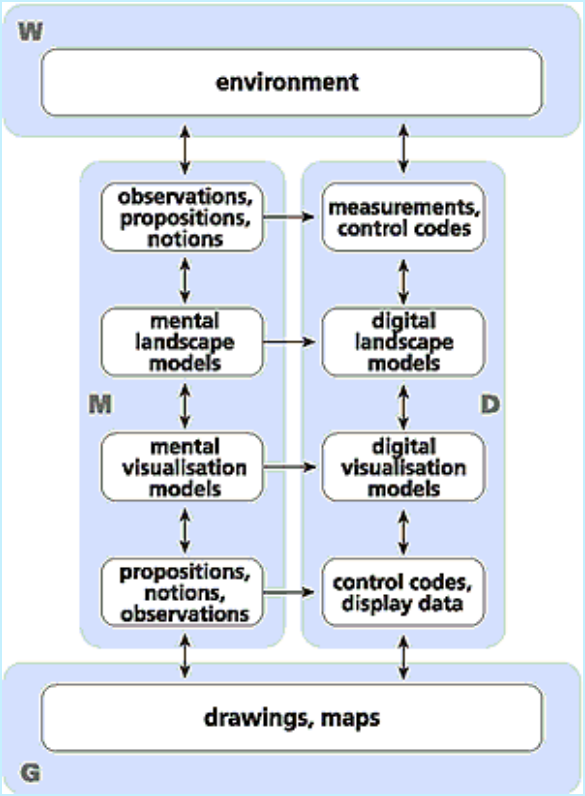

Figure 1: Model of representation of the real world in visible graphic images (R. van der Schans, 1995). W= real world, M = mental model , D = digital model , G = graphic representation.

Before maps can be used by children, they have to first learn about their environment, they have to learn about representations, and they have to learn to match the two (just as is the case with learning a language: children have to learn to link specific sounds to specific mental conceptions of their environment and objects in that environment). We can visualize this development by using the same general scheme as in figure 1, even if not all the links are established yet (figure 2A).

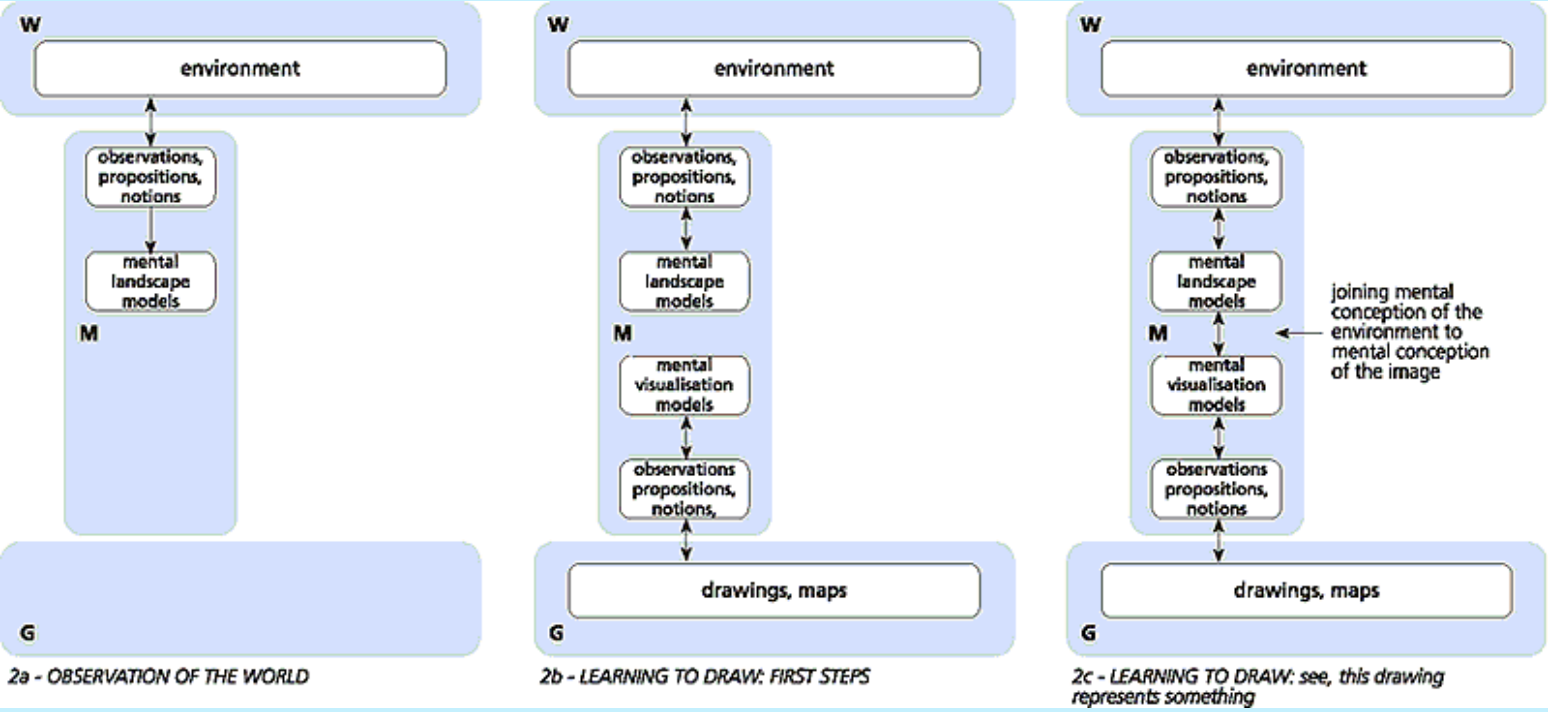

Figure 2: Stages of development (after R. van der Schans, 1995): 2a) Children develop a coherent image of their conception of environment; 2b) Children learn to draw; 2c) Children will gradually discover that drawings can represent (parts of) the environment.

In the first stage children will gradually, by feeling, viewing and smelling, develop in their minds a coherent image of their conception of their environment. In the second stage (figure 2b), when motory control over their movements has increased, children will be stimulated to draw, with paper and crayons e.g., and this self-expression will be encouraged. And finally, from about the age of 2.5 years onwards, the child will gradually discover that these drawings can actually represent something: the mental representation of the environment and the mental representation of the drawing are matched (figure 2c). And this is of course the grandest concept that we can develop from a cartographic point of view - that these graphics actually represent the mental model of our environment. When we apply this to current pictorial map use research (Wiegand and Stiell 1996), children will detect pictures and discriminate between them in the first step (lower end of the "M" column in figure 2c), will identify the pictures (depending on their experience with forms of representation and the phenomena themselves) when building the mental visualisation model of the map, and interpret the meaning of the pictures when adding to their mental landscape model.

At a later stage we will discover that it is possible to actually do something with these graphics or maps, to derive information from it ourselves or to convey information about the environment to others, to analyse it and interpret it. What a child can see on a map and can conclude from it, the information it can derive from it, will depend on its ability to use map skills. These, in turn, can be seen as an operationalisation of its knowledge of map concepts. Without knowledge of (and the ability to operationalise) concepts like scale, symbolization, generalisation, location or orientation, these skills cannot be developed. But one should add to this that, without extending our set of cartographic or map concepts with geographic ones, children will not be able to move beyond simple map reading tasks. Even so, we should stress that the major and first step in map use is the development of this basic concept of the map as a visual representation of our view of the real world.

The questions put by Anderson and Vasconcellos (1995) are relevant here: what concepts are required to allow children to derive information from maps, what is an appropriate sequence for introducing the concepts, and how can they be introduced to children. They refer to map reading skills as I understand it. I will concentrate in responding to these questions by covering the contributions made to these issues in the Netherlands, focussing on ways map analysis skills in secondary education can be improved by training.

2. Setting the stage: teaching materials and teacher expertise in the Netherlands

Atlases

In the Netherlands we have had special school atlases for primary education since 1830 (Prinsen 1830). As all atlases printed in the Netherlands from 1570 up to 1940 have been inventoried and extensively described by Utrecht University Cartographers (Koeman 1985), the school atlases subset of this larger data base is readily accessible.

When this subset is studied, some cycles emerge. The main cycle phenomenon (Van Keulen 1987) consists of the gradual elaboration and refinement of published atlases in their consecutive editions, by which process the atlases not only become more detailed but also more expensive. As a reaction, (societies of) primary school teachers start producing rather crude loose-leaf series of maps, at nominal costs, that are again accessible to all pupils. Some of these private endeavours are so successful that they are turned into commercially marketed teaching aids, and the whole cycle begins again. Whereas paper atlas production is now getting acknowledged more or less as a specialist occupation, we see geography teachers developing atlas-like products in new areas, i.e. for new media: electronic and multimedia products.

Two other cyclic developments can be discerned: one is the alternating view of an atlas as a learning utensil and as a reference tool. The atlas as a learning aid shows only those objects that should be memorized, completed by skeleton maps, and by images that should make the students familiar with map use. The other view would tend to provide a more balanced and complete scope, without bias for specific regions or themes. The last cycle to be discerned, at least valid in a small country like the Netherlands, is the alternation between autonomous development of educational ideas and their implementation in school atlases, and the copying of foreign ideas, from countries that are surmised to have higher standards of school cartography. Adoption of foreign trends can be detrimental. An example is provided by the school atlases of Gerard Prop (1935) published in the Netherlands, from 1910 to 1938. Prop applied land use or vegetation colours (see figure 3), or natural colours as we would call them now, to his atlas maps, before he was forced to adhere to the more prestigious example of German school atlas maps that showed hypsometric tints. The trend that is now emanating from Sweden and Germany since the 1970s actually prescribes the use of natural colours again instead of hypsometric ones.

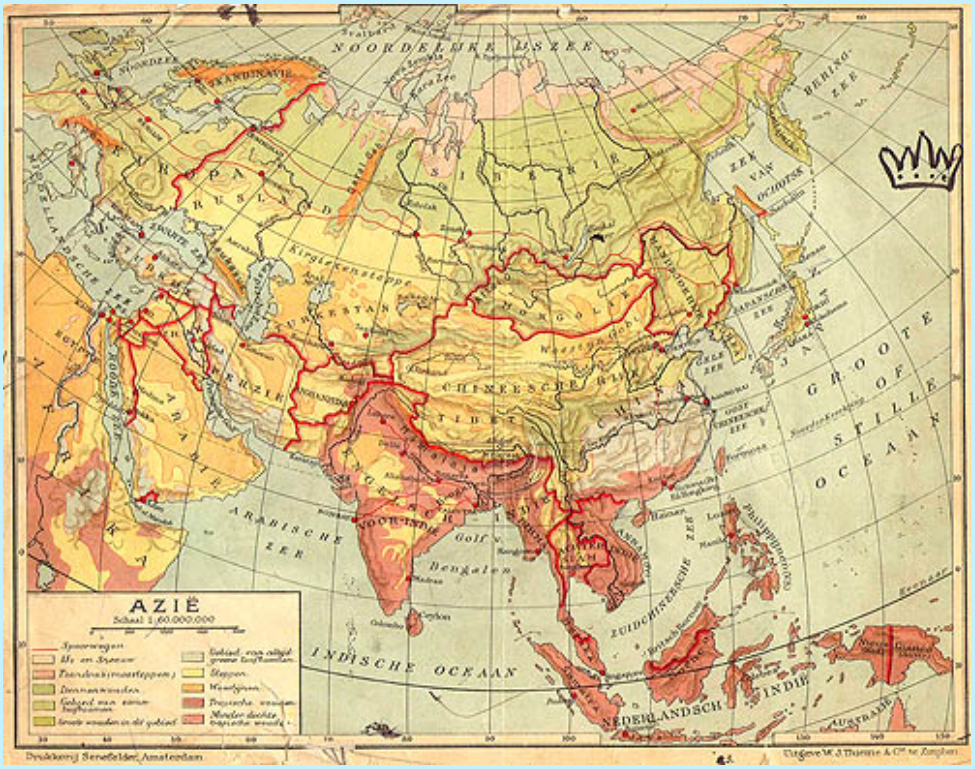

Figure 3: The map of Asia from Prop's Atlas van Europa en de Werelddeelen voor de Lagere School. Zutphen, 1935.

Manuals

Most geography manuals for secondary schools in the Netherlands do have some coverage of map use. In order to promote this, a number of map concepts are introduced by them. The author investigated the frequency with which all map concepts were tackled and introduced in the texts of the 10 manual series available in 1974, and he found the following results (table 1):

graticule/coordinate systems	9 times
scale	8 times
map use, map interpretation	7 times
projection, distortion	7 times
symbolization (use of colours)	6 times
aim, function of maps	5 times
aerial photographs, topographic maps	4 times
generalisation	3 times

Table 1: Frequency of coverage of map concepts in geography manual series in the Netherlands, 1974

This (table 1) shows an overemphasis on technical concepts, and a lack of coverage of the communicative, analytical or informative aspects of maps (such as legends), and this is still the norm for current manuals as well. Van der Schee (1985) found that maps in the two most popular current textbook series were largely aimed at showing spatial distributions, but hardly concerned themselves with spatial association or spatial interaction. Where spatial association was touched upon, it referred to **vertical comparisons** (what different phenomena occur at the same site?) and not to **horizontal comparisons** (what is the influence of different locations on each other?). The way in which these two textbook series covered map use was analysed as well (Spoon 1987). The number and proportion of maps in the manual series was determined, they were assigned a complexity rating, and subsequently the influence of this complexity on map use exercise questions was ascertained. This study drew heavily on the age groups and graphicacy skills discerned by Boardman (1983). Significant differences between the British and Dutch approach to map use in schools became apparent: in Britain direct training in map reading skills appeared to be a regular part of the geography curriculum, whilst in the Netherlands geographical concepts held a central position, and maps were mainly used to illustrate these geographical concepts. The highest level of graphicacy skills discerned by Boardman could not be found in Dutch texts or exercise problems. Only a fraction of the skills identified by Boardman were actually tested in the Dutch manuals. This situation still continues: in the 4 most used methods in 1996 half the map use questions still asked to identify map objects (map reading question), a third asked to classify map data, and higher order analytical questions only accounted for 16% (Van der Zijpp 1996). This was despite the fact that, in the curriculum requirements, it is stated that all pupils have to be able to read and analyse maps, and be able to use them in drawing conclusions.

Examination papers

Although so little attention was paid to map reading skills in Dutch geography textbooks, map use problems account for at least a quarter of the questions in examination papers in the Netherlands. The map use questions posed in examination papers were analysed (Hengeveld 1986). Analysis of them showed a complete lack of marginal information on the maps, a third of the maps showed construction methods not suited to the subject matter, and even for those that were constructed properly many were too complex or showed insufficient contrast.

Teachers

Perhaps this low quality of the exercise or examination maps is not to be wondered at, as examination questions in the Netherlands are drawn up by geography teachers. A survey of map analysis skills of Dutch geography teachers in 1986 showed that they scored hardly better than secondary school pupils in the map analysis tests (De Waard 1986). Anderson and Vasconcellos (1995) signal this as a world-wide affliction and blame it on the fact that the present map use literature does not provide the necessary guidance for training teachers to instruct children of different abilities to understand and work with maps.

3. Improving map use skills through programmed instruction

The main contributions to the improvement of map use skills in the Netherlands were realised through the geographic education research programme at the Free University in Amsterdam, where a team of geographers were engaged in research into general map use education issues.

The main contributions of this research group have been the demonstration that programmed instruction could improve map analysis abilities significantly (Van der Schee 1987) and that, in order to score even better results, geographical concepts relevant for map analysis should be taught prior to the execution of map analysis tasks (Van der Zijpp 1996).

The general framework they worked in is one of the subdivision of map use into map reading, map analysis and map interpretation. As indicated above, this can be equated to the lower left part of the general model (figure 2c) we started with; see figure 4.

"Map reading includes identifying and naming phenomena on a map. Map analysis includes two stages: classifying phenomena and discovering relationships between phenomena on a map. Map interpretation refers to the student's ability to explain spatial relationships between phenomena on a map on the basis of other information. To interpret a map, the geographer not only needs to be able to identify, classify and relate (procedural knowledge) but also to possess relevant declarative knowledge." (Van der Zijpp 1996 p 151). Procedural knowledge is the knowledge of the actions necessary to get from geographical facts to geographical generalisations, explanations or forecasts (Van der Schee et al 1992, p. 92). Declarative knowledge is the knowledge generated by reading or collecting of facts.

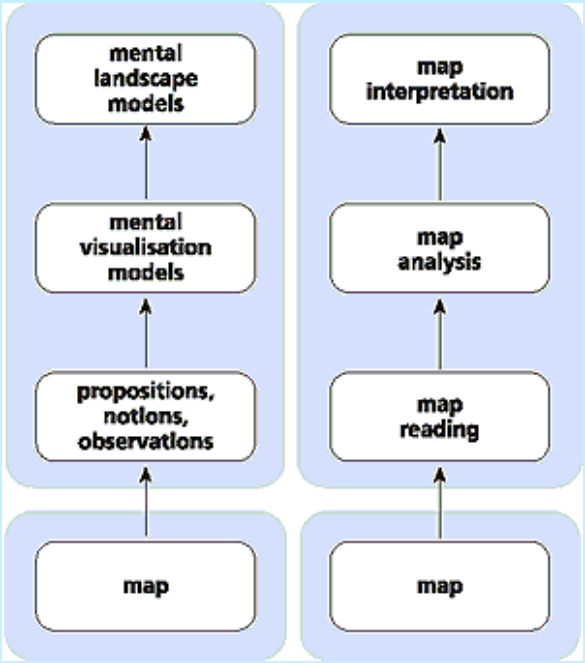

Figure 4: Comparison of the general map use framework (to the right) with the map production/map use model adhered to in this paper

Van der Schee et al (1992) indicate that what users will observe on a map during map reading will depend on their ability to use map skills. This is regarded by the present author as an operationalization of map concepts. During map reading, someone who does not understand the legend concept or the scale concept cannot identify phenomena on maps. On the other hand, it can be surmised that what users come up with during map analysis will depend on their operationalisation of geographical concepts. During map analysis, someone who cannot classify facts into spatial distribution and areal differentiation (by using the generalisation and regionalization concept), or who cannot discover areal association, is not able to analyse a map.

On this basis Van der Schee and Van der Zijpp developed geographical teaching material, aimed at developing geographical procedural knowledge in order to improve the execution of subject-specific map-analysis tasks. The procedure developed in both programmed instruction and individual remedial teaching consisted of teaching to perform a map-analysis task of relating phenomena on a map by following this sequence of steps:

1. What is on a map (identifying)
2. What is where on the map (classifying)
3. Do you see a relationship on the map (relating)
4. Check if this relationship is valid for each region on the map (checking, monitoring, validating).

To follow these steps presupposed the acquisition of knowledge of a number of geographical concepts. These are listed below:

underlying skills	**relevant concepts**
Describing/identifying	- spatial location: site, situation
Classify	- distance - spatial distribution: group
Relate	- spatial association: horizontal, vertical - spatial interaction - spatial system, region
Interpret	- spatial structuring of areas

Table 2: Relationship between map use skills and relevant geographical concepts.

Both location and distance have absolute and relative connotations. To perceive a number of occurrences as a spatial association, and to group them, presupposes the ability to generalise. Spatial association can refer to the interaction of different themes in one location, the interaction of the same phenomenon at different locations, or a combination. A spatial system is a complex of elements that are interacting with each other and together have an external function. In order to have this function some internal structuring is required.

In table 3 the relationships between the map use phases and map use skills are explained and they are related to the geographical questions asked.

map use phase	**geographical questions**	**skills needed**
map reading	what?	describe, identify
map analysis	where?	classify, relate
map interpretation	-why there? -what will it lead to is this apt? -how can it be developed	explain forecast evaluate evaluate

Table 2: Relationship between map use skills and relevant geographical concepts.

So in the exercises that form part of the programmed instruction, this is the sequence of map tasks, and this constitutes the procedure children are taught. If they do not perform on a higher order question, they are taken back, step by step and are made to follow the proper sequence of map use actions.

It is this same sequence, consequently, that the accompanying concepts have to be taught in (see table 2), in order to

allow for a meaningful map use training.

5. Relevance for Cartographic education and training

Cartographers have developed tests for ascertaining the efficiency of their map designs for information transfer. These tests consist mainly of tasks, the answers to which can be measured in terms of time or percentages of correct answers. Essentially these tasks are map reading tasks and not map analysis tasks. Map analysis tasks may well be much more important than simple map reading tasks, but cartographers have not yet developed the tools for performance measures nor relevant scoring methods in order to assess the suitability of their designs for these map analysis tasks. The procedural methods, like those developed by Van der Schee, using concepts, may well help cartographers to test map designs for higher level map analysis tasks.

What guidelines for improved map use education have emerged? We have not worked out yet what sequence should be selected for teaching the map concepts concerned in map reading (like scale, projection, legend, symbolization, generalization, location or orientation). But once one passes to the next phase, that of map analysis, the selection of concepts and of the sequence in which they should be taught has been made clear, and apparently the necessary concepts are geographical in nature (see table 2).

The main contribution of Dutch map use research then, from a cartographic point of view, has been a) to demonstrate that programmed instruction, on the basis of conceptual knowledge and its operationalisation, can improve map analysis abilities significantly (the fact that the degree to which students are able to employ a range of concepts when analysing maps can actually be extended by training, is important for cartography) and b) to open up new possibilities for testing map design.

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