Which place for Spatial Modelling in GIS education? The example of the GITTA project

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Abstract

The GITTA project covers the overall matter of Geographic Information Sciences (GIS). Spatial modelling (SM) is the particular theme of GIS as it is everywhere in the life cycle of Geographic Information (GI). No analysis without modelling, no database without modelling, no data capture without modelling, etc. Thus SM could be tackled in every module of a GIS course such as spatial analysis, data capture, databases. The course structure proposed for the GITTA project introduces two modules of one ECTS (European Credit Transfer System) unit each entirely devoted to SM.

The particularity of SM induces that the content of the SM modules is narrowly related to the others. Deciding the place of particular modelling notions during the integration phase of the content of the modules is of prior importance. This requires that we precisely settle the frontier between modules by clearly explicating the links between modules according to their structural line. The paper aims at bringing some elements of reflexion on the enhancement of the quality of the structure and content of the GIS courses by dealing with the central issue of spatial modelling.

Introduction

The Federal Program "Swiss Virtual Campus" aims to develop easily accessible web-based teaching modules for basic and specialized studies. The GITTA project (*Geographic Information Technology Training Alliance*), part of this program, aims to fill the gap of growing demand for a broader access to educational Geographic Information (GI) material by providing better and more coordinated access to comprehensive *and* in-depth information across a broad range of interested disciplines. The project develops a *modular structure*: A common *Basic Module*; an *Intermediate Module* extending and deepening the knowledge presented in the basic course; *Case Studies* for in-depth projects in representative application domains; and *Advanced Modules* covering special topics situated towards the end of the curriculum.

Redesigning GIS modules on the basis of existing courses in order to provide high quality web-based GIS teaching requires strengthening the coherence between modules of the overall defined GITTA structure. The GITTA project gives a great place to spatial modelling (SM) topic as it integrates two basic and intermediate SM modules of one credit unit each.

The GITTA SM modules are tackling issues such as: What is spatial information? Why and how to model space from observation? What are the current models? How to model particular phenomena? How to answer specific modelling needs? How these models are used in practical applications?

As modelling is a central theme in GIS education of major importance for all the other topics, the SM modules content needs to be defined by designing and explicating the links with the other modules.

Modelling is everywhere: model data for data capture, models used in GIS software, modelling tools for database design concept models, for data indexing, for spatial analysis, for cartographic modelling, etc. Which topics should be treated inside SM modules? How can these links be highlighted?

In this paper, we are dealing with the place of spatial modelling in the basic and intermediate GITTA modules in the GITTA project. Spatial modelling is a topic of prior importance that has a great incidence on all the other modules.

The first section of the paper presents the GI curriculum as it is structured in the GITTA project. Next section presents the content of spatial modelling modules. The core section expresses and details the links with the other GITTA modules while discussing the importance of emphasizing the teaching on spatial modelling within GI education curriculum.

The GI curriculum in the GITTA project

Among the long list of advantages provided by WBT (Web Based Training) when moving from classical classroom GI education to WBT according to (Horton, 2000), one of major lies in the enhancement of the quality of the structure and the content of courses. Usually, several critical points can be pointed out in classical GI curriculum, even if the overall GI course may be easily structured by following GIS from design to use:

- The lack of link and consistency between the different materials tackled, that may produce overlaps in teaching and confuse students,
- The difference of quality between modules,
- The place devoted to spatial modelling aspects usually too short or even inexistent, or at the end of GI curriculum.

The GITTA project aims to design a modular course structure which is based on the following structural elements. The ***modules*** are an educational component which (1) bounds a specific field of knowledge and (2) leads to well-defined knowledge and/or skills. ***Units*** are an amount of course work which is (1) a functional part of a module and which (2) corresponds usually to 1 credit unit CU (0.5 CUs and multiples of CUs are possible). ***Credit Unit (CU)*** corresponds to one unit of the ECTS (European Credit Transfer System). In terms of workload 60 credits represent one year of study (SwissVirtualCampus).

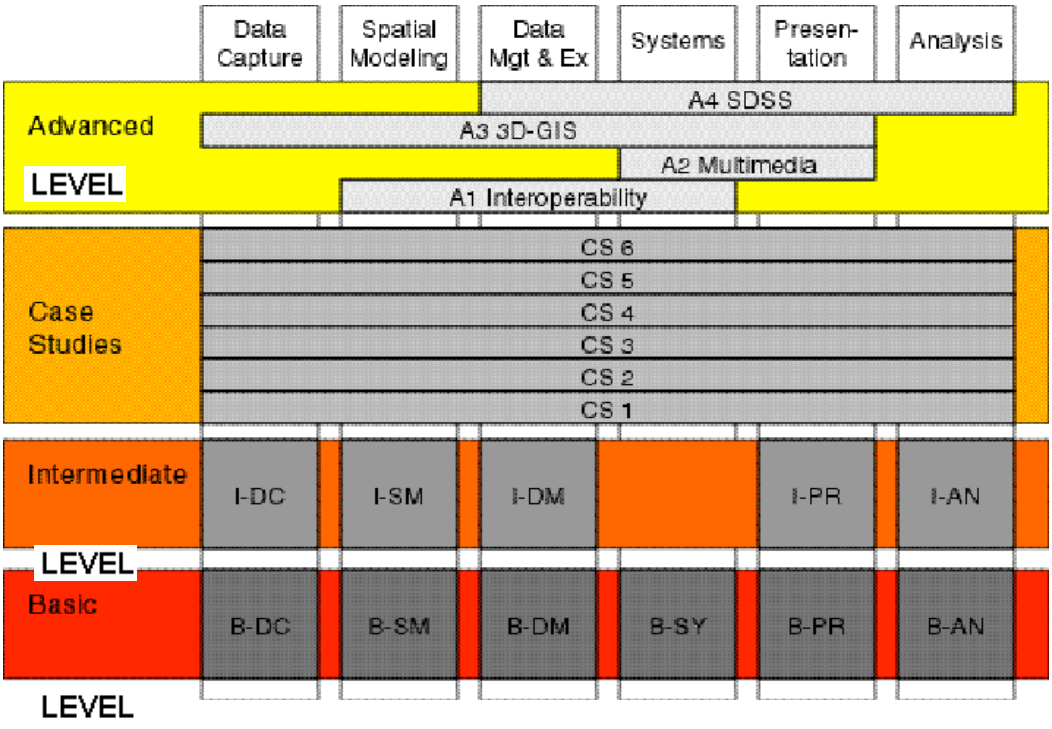

Figure 1: Pedagogical approach — GITTA shell model (2)

The ***Modules*** "Basic", "Intermediate", "Case Studies", and "Advanced" form the implementation of pedagogical objectives. The modules are broken down into *units* which are the basic structural element, defined in Credit Units (in terms of workload and expected results, respectively). It is important to note that students may stop the curriculum even after the basic level, according to their needs. For more details, you may read the paper from Eric Lorup, the GITTA project coordinator, also presented in EUGISES 2002 (Lorup, 2002).

Each Module touches on a number of ***Methods and Techniques*** as well as their applications, including "Spatial Modelling" (called SM), "Data Capture" (DC), "Data Management and Exchange" (DM), "Analysis" (AN), "Presentation" (PR), and "Systems" (SY) – cf figure 1. In the Basic Module, foundations and basic methods in each of these technical domains are introduced. In the Intermediate Module, the knowledge of these techniques is further refined. The level of abstraction is higher. The techniques that students learn are less frequently tackled but more specialized. The Case Studies, then, again involve the full breadth of methods and techniques, however this time, the focus is on solidifying the theoretical knowledge in a case-based and trans-disciplinary study. Finally, units of the Advanced Modules concentrate on more specific issues and provide in-depth information on selected techniques (GITTA).

Proposing a new structure for the GI curriculum, the GITTA project fills the gaps previously mentioned for the following reasons:

- The new structure bring consistency between modules in order to globally enhance the quality of the overall curriculum and provide a clear view of the links between GI modules,
- The rewriting of the content of the modules improve the quality as the project provides a common framework for involved development teams,
- The proposed structure provides a large place to spatial modelling topic by assigning two modules, basic and intermediate, of one credit each on a total of respectively 4 and 6,
- The SM modules are supposed to be the first modules that initiate the GI curriculum.

The content of spatial modelling modules

Spatial modelling is a first step theme, of importance for all the other topics of Geographic Information Sciences (Caloz and Collet, 1997). Hereafter the paper presents the content of the two GITTA Spatial Modelling modules that we currently settled. Our approach and the related reflections in designing their content will be discussed in the next sections.

Basic Spatial Modelling module (B-SM)

The basic spatial modelling module (B-SM) addresses the theoretical aspects for observing and abstracting real world geographic space and phenomena into spatial data structures. The module aims at developing sound fundamental understanding of the nature of geographic space and its perception and representation in digital models. The structure of B-SM module follows the modelling process of a geographic information system, going from observation throught digital spatial models to database modelling. We are dealing here with fundamental modelling from a general perspective without considering a particular application, even if in pratice the modelling process is obviously guided by an objective.

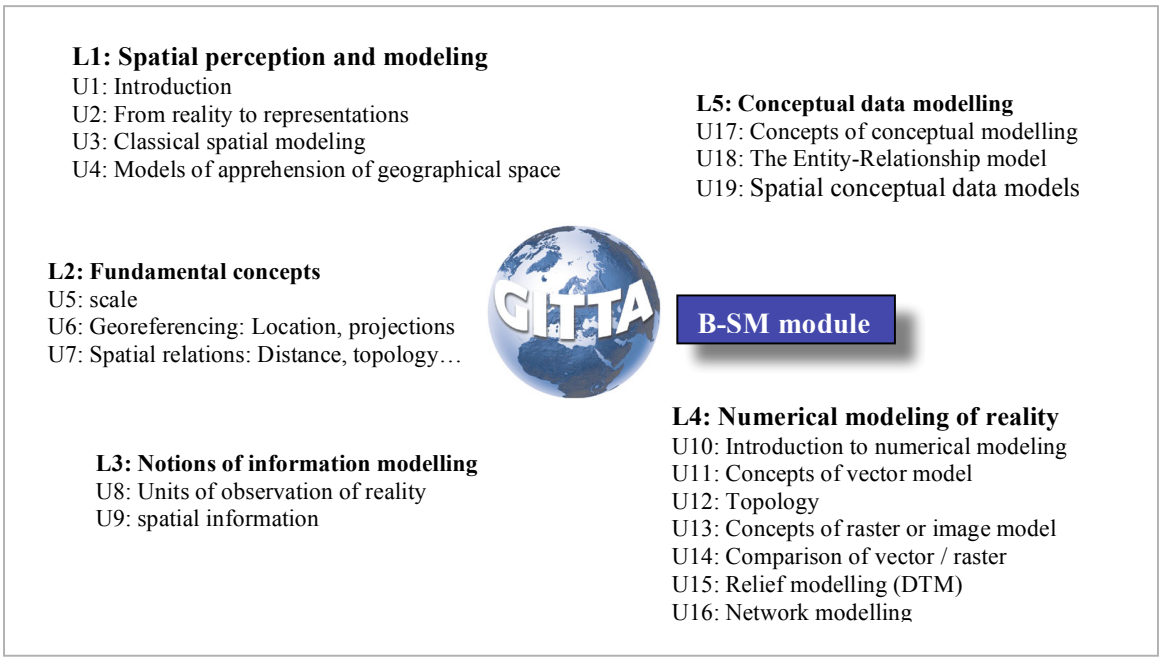

Figure 2: Structure proposed for the basic spatial modelling module (L for lesson, U for unit)

In lesson 1, the key problem is: How to formalize spatial reality ? The learning objectives are to: introduce the issue of modelling, the cartographic modelling as the conventional way and the apprehension of space as discrete or continuous. Lesson 2 presents the fundamental spatial concepts such as scale, georeferencing, spatial relationships as a basis for further developments in the module. Lesson 3 tackles the issue: How to describe spatial objects ? It consists in presenting required concepts, and defining observation spatial units and their properties, and spatial (digital) information. Lesson 4 key issue is: The digital modelling process – which steps are involved? It is the core of the B-SM module, presenting and comparing the 2 fundamental models: vector and raster. The lesson 5 dealing with: *how to design a database?* has for learning objectives to present conceptual modelling notions and spatial conceptual modelling specificities. The figure 2 provides a graphical outline of B-SM module as lessons and units.

Intermediate Spatial Modelling module (I-SM)

While B-SM module tackles fundamental modelling from a general perspective without considering a particular application, the intermediate module (I-SM) deals with modelling regarding to the objectives. The I-SM module tackles models that are more abstract, models based on the spatial feature properties or models that are objective oriented less classical but more efficient. It extends basic understanding to more complex models devoted either to particular phenomena such as relief, network, surfaces, etc. (lesson 1), to specific needs for spatial analysis or database indexing structures (lesson 2), to the special issue of interoperability in GIS as more and more applications require data from different sources (lesson 3), and the technical issue of modelling from an engineering point of view (lesson 4). The figure 3 shows the proposed content in lessons and units.

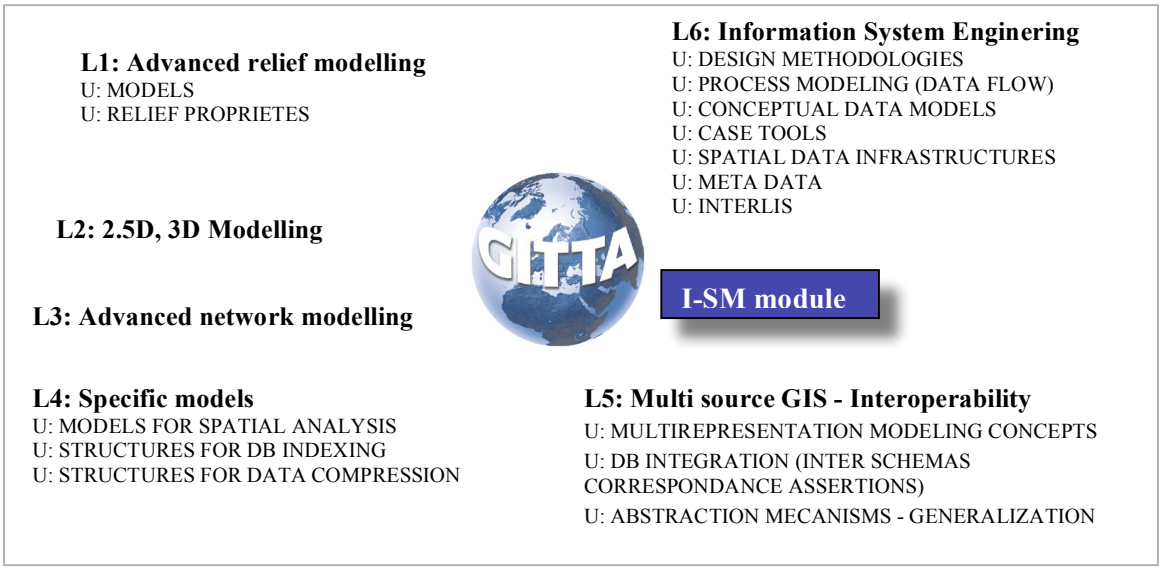

Figure 3: Structure proposed for the intermediate spatial modelling module

Integration in the GI curriculum

In order to evaluate the contents proposed for the B-SM and I-SM modules by themselves and according to the other GITTA modules, we have to pay attention on their structural trend line. A logical structure well defined and formalized should guaranty that the set of concepts tackled covering the topic is exhaustive, and that the content is consistent regarding the other modules in order to avoid as far as possible redundancies when they are not justified.

Spatial modelling modules outflow

The figure 4 hereafter illustrates the outflow links for the SM modules towards the other GITTA modules. On the right the different modules materialized as boxes follow the standard process of geographic information system management and use. We can see that modelling is required everywhere along the process. Therefore there are links at every level from B-SM and I-SM modules towards all GITTA basic and intermediate modules.

The structural trend line adopted for the GITTA basic B-SM module is process oriented. The intermediate I-SM module follows a model and phenomena oriented logic. The definition of the frontier with the other modules is certainly arbitrary, but it is necessary to settle one in order to provide an exhaustive GITTA content and clear links to the students between the contents of the modules.

Such a schema brings us to ask questions about the content of the spatial modelling modules that will allow us to settle definitions of the links with the other GITTA modules that we develop in the next section.

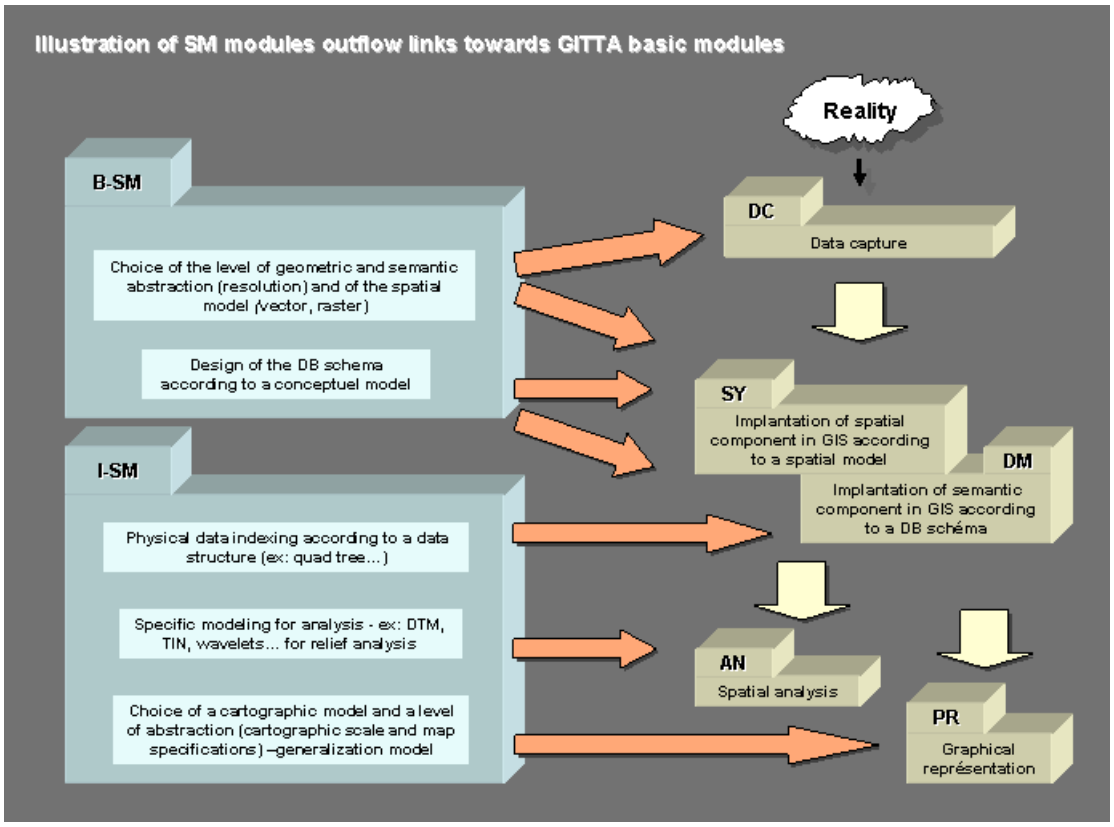

Figure 4: Spatial modelling modules outflow

Which notions in which modules?

One of our major concerns when designing the SM modules content lies in answering the questions:

- Which notion in which module?
- Which notion at which level?

Besides the fact that a notion have to fit within the logical red line of a module, the choice of developing it in a module rather than in another one depends also on the ECTS credit affected to the modules and the complexity of the notion.

The figure 5 below provides examples of notions that may be considered as being at the frontier between several modules.

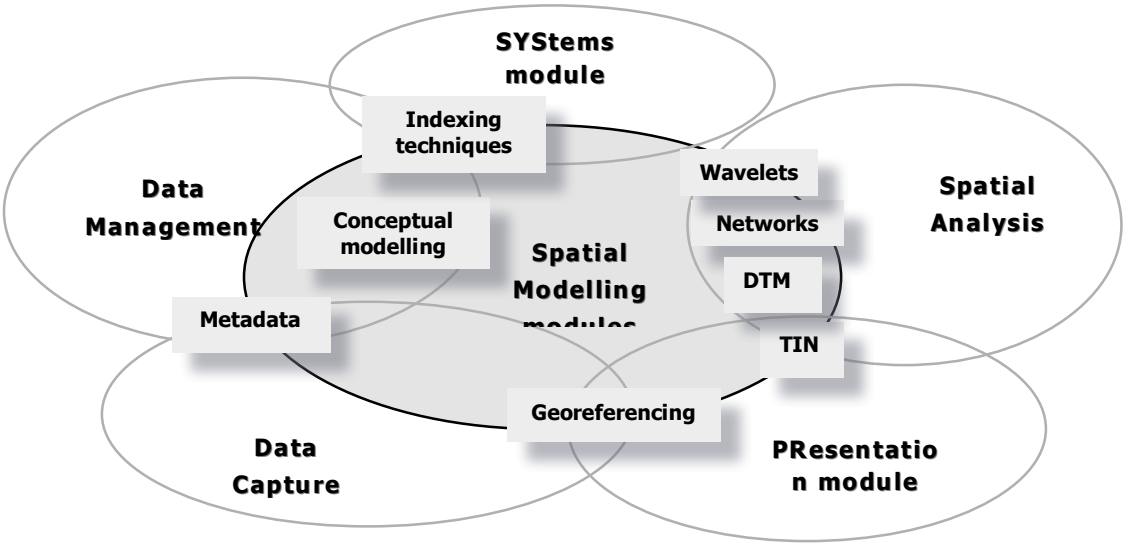

Figure 5: Example of notions at the frontier between modules

In the following, we take a few open questions on the place that some notions should have and try to answer for the GITTA project.

- Is Network modelling in spatial modelling (SM) and spatial analysis (AN) modules?

  There are a lot of possible overlaps between the AN and SM modules, as spatial analysis requires a modelling step transforming the initial data model of reality for analysis purpose. Furthermore we may say: *no spatial modelling without analysis. No spatial analysis without modelling.* In this sense it is very important to provide clear definition of the links we put between these modules.
  As an example, network modelling is an important spatial analysis issue. I-SM could contain route modelling while the I-AN module will present the route computation issue. The figure 6 below shows the links through the example of road network modelling and use.

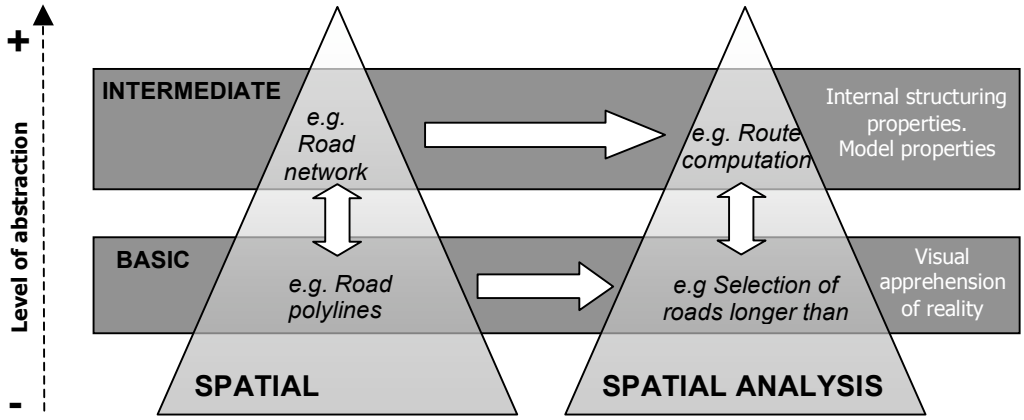

Figure 6: Links between GITTA SM and AN modules illustrated through an example

- *May terrain modelling be considered in SM module, in AN or in a case study, or even in the advanced 3D GIS module?*

  Another important GI notions at the frontier between SM and AN is terrain modelling, as terrain remains a feature of the territory of major importance and as it is complex to model. Furthermore some students may not take the advanced levels depending on the curriculum they are following. Thus terrain modelling has to be tackled at the basic level of GITTA, in the B-SM module dealing with basic modelling aspects (mainly Digital Terrain Models), and in the B-AN module dealing with terrain analysis problems such as slope computation. Other modelling tools such as TIN and terrain properties such as structural lines should be tackled in I_SM while advanced terrain analysis is developed in I_AN.

- *May techniques for representing information such as wavelets or fractals or TIN be developed in SM or AN modules?*

  According to the links defined in the figure 5 above, we will treat these particular modelling techniques in the intermediate I-SM module from the modelling point of view, as a modelling tool in order to extract structuring properties of the objects for further analysis and computation to be developed in the I-AN module.

- *Should conceptual modelling be tackled in Data Management (DM) module or in spatial modelling (SM) module?*

  Conceptual data modelling may be tackled in B-DM module as well as in B-SM module. It consists in structuring alphanumerical data, answering on what information is important for the application, in which spatial model… In this sense it can be considered as part of the modelling process instead of viewed as a database tool…
  (Molenaar, 1995) provides a synthetic view of the levels of data modelling in the GIS design process that allows to illustrate in an adequate way the link between the B-SM and B-DM module. The figure shows that mainly spatial and conceptual modelling topics are of our concern. Logical data modelling and physical modelling should be presented in the Data Management module which is computer science oriented.

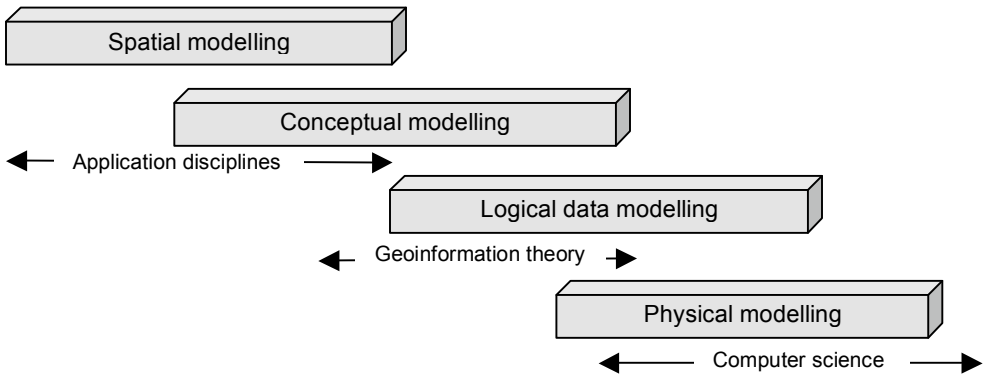

*Figure 7: Several levels of data modelling, adapted from (*Molenaar, 1995*)*

Another major reason to develop conceptual modelling in the B_SM GITTA module lies in the ratio between ECTS credit affected to each module and the content that needs to be provided at least. The B_SM module equals one ECTS credit unit while the B_DM module has an affectation of half credit, which should be correct only to present mainly the logical relational model and the SQL query language.

- *Should indexing structures be treated in Data Management (DM) module or in spatial modelling (SM) module?*

  Indexing methods are mainly devoted to DBMS optimization access to data. It may also be considered as a way of structuring spatial information from the model of reality. In this sense it could be treated as a spatial modelling aspect. According to the definition of the link that we settled, we may say that indexing is a computer science issue, as it concerns the access time optimization to the data.

- *Should georeferencing notions be presented in SM, even if there are more adequate in DC or PR modules?*

  The spatial notion does not have any real meaning without the relation to a metric (location of spatial features one to each other, size of the features, etc.). In this sense, it has to be tackled in B-SM and further developed in B-DC or B-PR.

- *Metadata may be presented either in B-SM, or in B-DC or B-DM.*

  Metadata may be considered as being as important as the data itself! Spatial Modelling consists in identifying spatial features. It is of prior importance to define them rigorously in order to guaranty their adequate use and exploitation. Complementary numerical information are added while inserting them in the database. In this sense, it has to be tackled in B-SM and further developed in B-DC or B-PM.

Conclusion

We have seen that the particularity of SM induces that the content of the SM modules content is narrowly related to the content of the others. In this paper we brought elements of discussions in order to integrate the contents of SM basic and intermediate modules within the GITTA course structure. These elements may be structured as following:

- We have presented the structure of the GITTA basic and intermediate Spatial Modelling modules as a basis of discussions about the place of particular modelling notions during the integration phase of the content of the modules is of prior importance.
- Then we have identified the major overlapping notions of the SM modules with the other modules, especially with the AN modules which are the more strongly related.
- We have defined the links between SM modules and the other GITTA modules according their structural lines.
- Finally we have precisely settled the frontiers between SM modules and the other GITTA modules and placed each important notion we have taken as example, such as the relief issue, in the adequate GITTA modules.

Criteria that we have identified in order to allow us to assess the content of the GITTA spatial modelling modules according to the others to guaranty the exhaustivity and the consistency of the overall GIS course content may be summarized in the following points:

- What notion is in the basic and what in the intermediate level?
  Even if a particular notion may be tackled in a specific module devoted to it, it has to be at least mentioned in basic level in an intuitive way before being further developed and specialized in higher knowledge level.

- Is a GIS notion better placed in a module rather than in another one?
  The choice of the place of a notion is obviously depending on the fact that it is correctly integrated in the structure line of the module. Furthermore placing a notion in a module rather than in another

one is also depending on a factor of homogenization of the length of the modules according to the credit unit they have.

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