Models and Modelling between Digital and Humanities: A Multidisciplinary Perspective

Ciula, Arianna (Ed.); Eide, Øyvind (Ed.); Marras, Cristina (Ed.); Sahle, Patrick (Ed.)

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Models and Modelling between Digital & Humanities – A Multidisciplinary Perspective

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Charles Tilly (1929-2008)

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Modelling: Thinking in Practice.
An Introduction

Arianna Ciula, Øyvind Eide, Cristina Marras & Patrick Sahle [*]

Abstract: *»Modellieren: Denken in Anwendung. Eine Einführung«*. In this introduction of the HSR Supplement "Models and Modelling between Digital and Humanities - A Multidisciplinary Perspective" we refrain from providing a normative definition of 'model' and 'modelling' and rather attempt at encircling the current state of the art. In the first instance this chapter provides a very brief overview on modelling as intended as a research strategy applied to scientific fields in the 20th-21st centuries. This overview is followed by a short introduction to modelling in digital humanities, focusing on how modelling has developed into a practical strategy and how it has been theorised. The third part of the introduction presents the scope of the project "Modelling between digital and humanities: Thinking in practice". The aim of a project workshop held in 2017, of which this volume collects the proceedings, was to present a multitude of modelling practices from various disciplines together with different theoretical frameworks. The fourth part of this introduction offers an overview of each of the papers in this volume. Finally, a fifth section constitutes the first item of the proceedings as it reproduces an adaptation of the dialogue which was performed to introduce the main topics of the workshop and the scope of the project at the event itself. It serves to illustrate the way we organised the workshop and how the exchanges amongst participants were facilitated.

Keywords: Modelling, Digital Humanities, Multidisciplinarity, Visualization.

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The editors would like to thank all the colleagues who, through their papers and discussions, significantly contributed to the workshop, to the project and to this publication. Thanks also go to the Theaterwissenschaftliche Sammlung, Universität zu Köln, for the interesting and inspiring guided tour offered during the workshop, which gave participants an insight into modelling practices in theatre. We also would like to extend a special thanks to Zoe Schubert and Elli Reuhl for their assistance and editorial help in each phase of the work on this volume and Chris Pak for his proof-reading work.

1. Modelling in the Sciences

Models and modelling as explicit explanatory, exploratory and empirical strategies of inquiry have been increasingly recognised and adopted in science and scholarship over the last decades. Popular examples of influential models in the natural sciences include the Bohr model of the atom, the double helix model of the DNA, and the Lotka-Volterra model of predator-prey interaction, whereas in the social sciences rational actor based models of economic transactions and actor-network models have been of key importance. Economic and climate models have also gained significant societal relevance and are at the core of political discussions. Society macro-planning and policy making are partly based on complex economic models, and climate models are increasingly used to justify resource planning at all scales, from municipalities to continents. Thus, scientific models are not only important in their respective research domains but are also adapted and adopted extensively in public policy planning and are prominent elements of the public discourse.

In contrast to its ubiquity, the concept of model is hard to define. Quite different things are called models: from physical and fictional objects through set-theoretic structures to mathematical equations, as well as combinations of some or all of these. Models are understood to be not just static representations but rather tools for interactive inquiry. Models and the process of modelling feature a number of often mixed ingredients, including different forms of expressions such as mathematical formalism and visual diagrams, as well as a variety of conceptual devices such as theoretical ideas, policy views, and metaphors. Models as computational construals can also embody quite different forms. To complicate matters, processes of translation between multiple expressions and conceptual worlds, such as abstraction and idealisation, make modelling a slippery practice to pin down conceptually. Typically, modelling is not linear. It is rather a complex iterative process of integration and exploration with repeated loops of testing, feedback and adjustment.

The relationship between models and their "targets", that is the objects or systems being modelled, is complex and hard to define, as is the nature of the target object or system itself (Gelfert 2016, 93). The scientific understanding of this relationship varies across research traditions and has developed significantly over time. In the 20th century, models have been described as as representations of their targets and the specific nature of the representations did not attract much attention until the latter part of the century. This has changed over the last decades, but the categories used to describe models, such as idealised models or phenomenological models, are still somewhat vague and the borders between them not clear. Furthermore, in philosophy of science, a pragmatic view on modelling has emerged over the last decade, in which the relation between a model and its target, traditionally expressed as representation in the form of formal, structuralist or syntactic morphism (such as isomorphism), is being replaced by emphasizing a pragmatic relationship, often simply described as a situation where somebody creates a model of something with some purpose (Gelfert 2016, 113).

Traditionally, prediction and reproduction of results, as well as explanation of observations, have been the main phases of the scientific method in which models in the sciences have been created and evaluated. More recently the creation and use of models to explore rather than measure, predict, or explain have also gained recognition in the philosophy of science.[1] All these functions are associated with what is considered the purpose of models, which is to support analysis and discovery as well as to enhance learning and understanding. Models are indeed considered to be better suited to learn something new about the target systems or objects for several reasons. Their creation and manipulation support surrogative reasoning, where aspects of the system under study are sharpened up in the model and hence made more "observable" than by studying the target systems or objects directly. The novel concept of model-based reasoning captures exactly this.

Learning from models can take place at two different stages, in the creation of the model and in its application and successive manipulation; that is, through changing it and observing the effects and reactions. Further, it can take place through physical experiments, thought experiments, and simulations. Of key importance is the fact that models often serve an exploratory function in research: as a starting point to test an hypothesis, as proof of concept, to generate potential explanations to a theory, and to assess what the target system is and how its salient features can be observed in separation from background noise (in cases where a firm theoretical understanding is not yet established, cf. Gelfert (2016, 93). Explanatory, experimental and explorative functions are distinct and central to model based scientific exploration, but they are neither mutually exclusive nor exhaustive.

The philosophy of science literature has been the venue of extensive debates on how models relate to theories.[2] This discussion is entangled with the difficulty of distinguishing between model and theory. From the logical positivist tradition philosophers of science have inherited the syntactic view, where models are understood in a mathematical sense as tools with which to perform calculus. In this view, where theories are seen as a set of propositions expressed in first order logic, models are seen as having limited importance for science. The semantic view goes in the opposite direction, claiming that theories should be seen as families of models. Here, formal calculus is removed from the core role it plays in the syntactic view. Beyond these views there is the position that models are independent both from theories and from the target systems or objects, being rather "autonomous agents". For example, according

1 See e.g. Gelfert (2018, 245).
2 See e.g. an overview in Frigg and Hartmann (2018).

to Morrison and Morgan (1999) models are autonomous in that they are not placed between a theory and the physical world but rather outside the theory-world-axis, enabling models to mediate effectively between the two.

2. Modelling in the Digital Humanities

The use of models and modelling also has a long tradition in the humanities. Indeed, going back to early modern European research the use of models in what could be called, pragmatically, "the humanities" included modelling in natural philosophy, which later developed into the natural sciences. The long history of modelling is complex due to the only partial overlap between the concepts of model and modelling then and what we consider as modelling practices today.

Nevertheless it is fair to say that the explicit use of the word "modelling" in humanities research has increased significantly with the introduction of Digital Humanities (hereafter DH), where modelling is considered one of the core research practices (McCarty 2005, 20-72; Buzzetti 2002; Beynon et al. 2006). The high reliance on modelling in this discipline is due to the fact that explicit models are extensively required in DH in order to operationalise research questions. This operationalisation process includes representation of objects of study in the form of data to process, in order to make objects and observations computable, as well as to analyse, transform and visualise data. The practice of modelling in DH is theorised mainly around understandings of modelling in the techno-sciences and computer science in particular (Flanders and Jannidis 2015), although some reference works in the field also take into account other research traditions from the humanities, social sciences and informatics (McCarty 2005, 2009; Mahr 2009). A key aspect of modelling in DH is the focus on interactive use of computers and on studying the modelling process with the aim of learning from it. The highly self-reflective arm of DH research, that some call a meta discipline to the humanities, engaged in assessing the epistemological impact of information technology and software engineering in research, calls for a shift from models as static objects (e.g. what functionalities they enable) to the dynamic process of modelling (e.g. how were models built and used and for what purpose, what constraints they embed, what effect they have in refining research questions).

Models as they are used in science and scholarship are representations – in the form of manipulable construals – of something which are created for the purpose of studying that something or what is modelled (what above was referred to as "target" following the tradition in philosophy of science). However, the relationship between model and modelled object is more complex than static representational understandings have allowed for. Only recently model-making has been theorised within a semiotic framework (Knuuttila 2010; Kralemann and Lattmann 2013; Marras and Ciula 2014).

In DH as in other scientific settings, modelling can be considered a creative process of reasoning in which meaning is made and negotiated through the creation and manipulation of external representations. The specific ambition of research in DH, however, is to make scholarly arguments operational via the creation and manipulation of digital models. Making external representations to reason with has been part of the scholarly Western tradition at least since the Enlightenment; DH extends this practice by actively creating and processing digital artefacts in different media.

In the DH context models are always created with the objective of been operationalised. This means that they are created in a way so as to lend themselves to be used and manipulated in a computational setting. However, the form models take can vary extensively, from a formal schema, to the logics informing the running of code (programs or apps) as well as to digital objects such as maps or 3D models. Such frameworks can be local to one institution, one project, or even to one single researcher, but can also be generalisable and scalable, as we see in the development of common formalisms or standards such as the recommendations of the *Text Encoding Initiative* (TEI) guidelines to encode textual sources. Modelling in DH is also akin to similar processes adopted in the area of cultural heritage documentation. The latter has traditionally focused on database development and associated documentation standards; dating back to the 1990s there has also been a development of formal ontologies, exemplified by CIDOC-CRM.[3]

What modelling in the (digital) humanities and (digital) cultural heritage have in common is partly the source or objects for the models (in general cultural artefacts of some kind) and partly the aim of the whole modelling enterprise. While in, e.g., physics the target of modelling activities are aspects of the physical world and the goal is the establishment of general laws, in the humanities and cultural heritage modelling targets tend to be human creations and the goal of the modelling is often to describe idiosyncratic phenomena or artefacts of human creation, acknowledging and valuing subjectivity as part of the modelling process. Often the objective is to express principles grounded to specific contexts rather than general laws.

3. Our Research Project on Modelling

Scholarly modelling as a formal and informal reasoning strategy across disciplinary boundaries was the core of the collaborative Project “Modelling be-

[3] See Ciula and Eide (2014).

tween digital and humanities: Thinking in practice”[4], funded by the Volkswagen Foundation under the programme “Original, isn’t it? New Options for the Humanities and Cultural Studies,” Funding Line 2 “Constellations” (2016-2017), from April 2016 to July 2018. The workshop, the proceedings of which are collected in this HSR Supplement, was one of the milestones of the project.

This collaborative project connected the research threads of the four Principal Investigators (PIs) and editors of this volume – Arianna Ciula (Department of Humanities, University of Roehampton, UK, until January 2017; King’s Digital Lab, King’s College London, UK, from February 2017 onwards), Øyvind Eide (University of Passau, DE, until March 2017; University of Cologne, DE, from October 2015 onwards), Cristina Marras (CNR-ILIESI, Rome, IT), and Patrick Sahle (University of Cologne, DE) – freeing them partially from other duties at their own institutions or allowing them to hire research assistants and associates[5] to take part in the research and to coordinate common efforts, including the organisation of the workshop in Wahn.

Through the lenses of critical humanities traditions and interdisciplinary takes on making and using models, the project built on the novelty of DH research in making explicit and integrating existing diverse models of cultural phenomena such as texts and events. Its originality laid in using DH research to explore possibilities for a new interdisciplinary language of modelling spanning the humanities, cultural studies and the sciences; to analyse modelling in scholarship as a process of signification; and to develop connections between modelling as research and learning strategies.

The following was used as working definition of modelling within the project: modelling is the creative process by which researchers create and manipulate external representations (“imaginary concreta”, Godfrey-Smith 2009) to make sense of the conceptual objects and phenomena they study. To integrate the theories summarised in the section above with a practical dimension, the project made use of DH as an interdisciplinary departure to study modelling as anchored both to computer science and to the humanities. The project aimed to link scholarly modelling as a formal and informal reasoning strategy across disciplinary boundaries, spanning also social, life and techno-sciences, and bridging across modelling in research and in teaching.

Building on complementary expertise in DH research, the PIs aimed at reflecting on modelling around the central concept of textuality. Textuality stands

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[4] <http://modellingdh.uni-koeln.de>.

[5] Research associates in the project were: Christopher Pak (King’s Digital Lab, King’s College London, UK, October 2017-April 2018), Zoe Schubert (University of Passau and University of Cologne, DE, November 2016-December 2017), and Michela Tardella (CNR-ILIESI, IT, July 2016-July 2017). Research assistants in the project were: Nils Geißler (University of Cologne, DE, April 2016-July 2018), Elli Reuhl (University of Cologne, DE, November 2016-July 2018), and Julia Sorouri (University of Cologne, DE, January 2017-July 2018).

for the complexity of cultural objects studied in the humanities and the theories that underpin these studies; it is central to most humanities and cultural studies and a perfect example of the variety of subject specific approaches that can inform modelling activities. An interesting attempt to integrate models of textuality from several disciplines into a metamodel to chart and relate single models to each other is Sahle (2013). Sahle's metamodel acts both as a model of the phenomenon of textuality and as a model for working with texts in the sense of representing, transforming, and analysing them. Therefore, this metamodel can inform the development of text technologies, digitisation practices, and rules for transcription and annotation.

The hypothesis underpinning the project was that in DH research, implicit and explicit models of cultural phenomena are integrated into external metamodels, e.g. graphical representations, which often embed natural language. These metamodels are iteratively translated towards computable implementations via a variety of more or less formal models. The analysis of modelling practices of textuality aim at gaining new insights in the epistemology of modelling in order to address questions such as: How are theory and practice blended in these modelling efforts? What role do formal and informal metamodels play in translating models of cultural phenomena into implementations? What shared terminology can help us gain an integrative and non-reductive understanding of digital modelling? Can we define the methods of digital modelling informed by such an integrative and non-reductive approach?

The core activities of the project included the organisation of the international workshop described below, the publication of its proceedings within the present issue, the delivery of a co-authored monograph, and a series of interdisciplinary labs.[6] The co-authored monograph, the writing of which is currently in progress, aims at integrating the results from these core research activities with the outcomes from the workshop to establish a common ground for further theoretical and practical research.

The project aimed at reflecting on two main concepts: textuality and events. While textuality mediates the world we live in, events are central to epistemological perception and description of the processes shaping this world. Under this umbrella three interdisciplinary labs were organised in Rome, at the Italian National Research Council's Digital Library, in 2016-2017: "I linguaggi della ricerca: parole e immagini" (The languages of research: words and images);[7]

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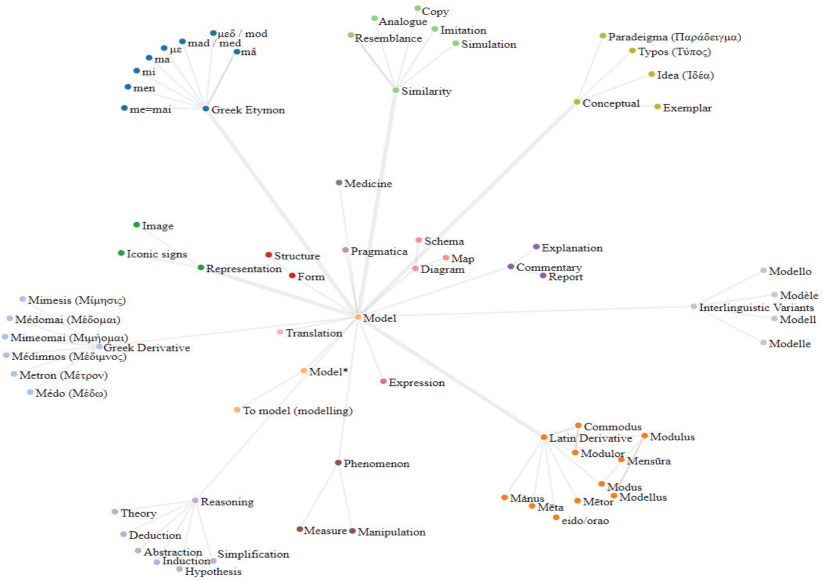
6 In addition, in 2016-2017, a total of 14 online and face to face project meetings as well as mutual research visits brought together the PIs and other team members. These meetings were held to reflect on and connect several research strands and to plan the project activities and its main deliverables.

7 Lab 1: *Riti, Passaggi, Visioni, Linguaggi* (Rites, Passages, Visions, Languages), 21 March 2016; Lab 2: *Navigare la Ricerca* (Navigating Research), 26 September 2016; Lab 3: *Naufragi e Terre Nuove* (Shipwrecks and New Lands), 22 May 2017. See <http://modellingdh.eu/index.php/events/> for further details.

these events were part of Cristina Marras' research line and teaching programme. The aim of these labs was to investigate the heuristic and cognitive role that selected conceptual metaphorical models, belonging to the traditions of Western thought, assume in structuring knowledge. Groundwork from philosophy, literary studies, history and linguistics was combined with cultural heritage documentation and media studies methodologies. While not directly engaged with digital modelling, the Rome labs paved the way for further research for which funding will be sought.

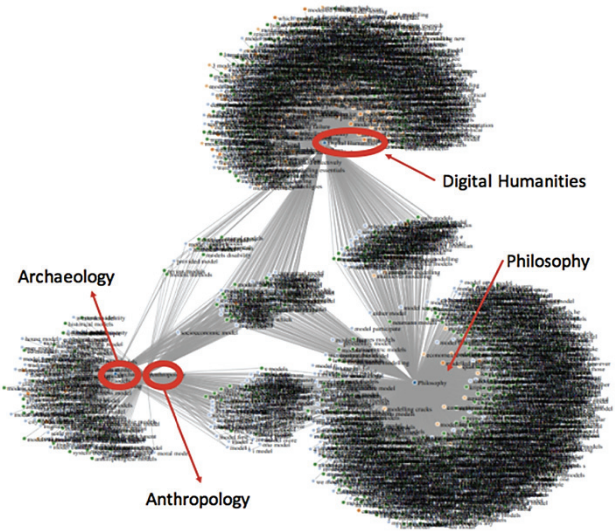
Figure 1: Snapshot Drawn on Preliminary Network Graph of Terminological Connections Developed in D3.js (see Pak 2018), Slightly Reworked by Nils Geißler

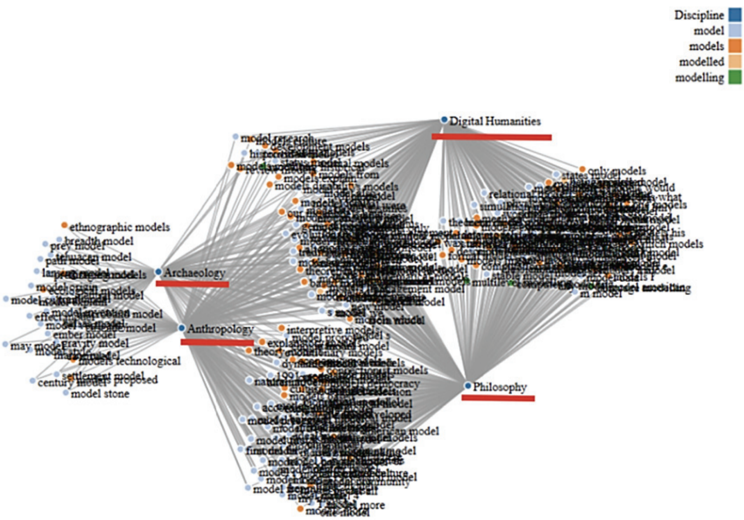


As complementary research strands to the core activities of the project, each PI hired postdoctoral researchers and student assistants to conduct some of the project research or to support its activities, and to free the PIs' time from other duties.

In particular, the Italian partner (Marras and Tardella) engaged in terminological and lexicographical research conducting a preliminary analysis of the terms "model" and "modelling" from a terminological and etymological perspective. The work was based on the assumption that the theoretical issues around modelling are deeply connected to the evolution of the relevant terminology, and that by reflecting on the terms and their relations a complex terminological network of underpinning concepts can be built. Based on the mapping of selected dictionaries, encyclopedias and etymological vocabularies to support this analysis, preliminary results confirmed that the complexity pertaining to theory and practices in modelling is embedded in the history of the terms "model" and "modelling". This work complemented ongoing research carried out in London and Cologne and offered a basis for further analysis and visualisations, undertaken by Pak (see Figure 1) and by Geißler.

Figure 2 and 3: Preliminary view of interdisciplinary connections developed in D3.js (Pak and Ciula 2018)





The UK partner (Ciula and Pak) developed a preliminary workflow for corpus linguistics research to process and analyse academic articles from five disciplines, published from 1900 to 2017. The workflow describes the parameters and methods for constructing and analysing a corpus of journal articles accessed via the JSTOR Data for Research service using corpus linguistics methodologies. Indicative findings show that model/ling is a networked term insofar as it co-occurs with semantically related terms defining structural relations between entities, such as "pattern" and "hierarchy." These preliminary findings provide the context for more extensive analysis into disciplinary-based discourses on the creation and use of models. Pak also developed visualisations to represent the results of this analysis.

The Cologne partner (Sahle, Geißler and Sorouri) worked at a case study on text models and model visualisation, based on a selective interdisciplinary literature survey on models for texts which led to a chapter in the project's monograph. Sorouri's contribution consisted of the translation of abstract or verbal models into new forms of visual representations which have been used in these proceedings and the forthcoming book.

The other German partner (Eide and Schubert) focused on the study of the connections across modelling, cultural heritage, and intermediality. Partly connected to cultural heritage (for instance, archaeological evidence) and partly connected to teaching, especially in the area of media modalities and virtual reality, Eide's research informed and has been complemented by Schubert's PhD on theatre in virtual reality.

In addition to the core activities mentioned above, the PIs and other team members gave numerous presentations at relevant conferences and events[8] to discuss the project premises and disseminate its findings. Either as a result of these conference contributions or other research connected to the project, several publications have appeared or are forthcoming (Ciula and Marras 2016; Ciula and Eide 2017; Ciula 2017a and 2017b; Ciula and Marras 2018 and forthcoming).

4. A Multidisciplinary View on Modelling: The Project Workshop

This Supplement of HSR stems from the contributions on modelling presented at the workshop "Thinking in practice", held at Wahn Manor House in Cologne on January 19-20, 2017. Practical examples of model building from different disciplines are presented and discussed, with the aim of contributing to the discussion of modelling in different disciplines, centered around DH as point of

8 For more details see <http://modellingdh.eu/index.php/events/external-events>.

departure. Combined with theoretical considerations, the collection illustrates how the process of modelling is one of coming to know, in which the purpose of each modelling activity and the form in which models are expressed has to be taken into consideration in tandem. The modelling processes presented in this volume belong to specific traditions of scholarly and practical thinking as well as to certain political contexts. The claim that supported the project workshop was indeed that establishing connections between different traditions of and approaches towards modelling is vital, being these connections complementary or intersectional. To underpin the project research aims was indeed crucial to examine the nature of epistemological questions addressed in the different traditions and how they relate to the nature of the modelled objects and the models being created. While this is only touched upon in this volume it will be further developed in the forthcoming monograph co-authored by the project principal investigators.

This collection is an attempt to move beyond simple representational views on modelling in order to understand modelling processes as scholarly and cultural phenomena in themselves.

As the objects being modelled take active part in the relational process of several modelling efforts, their identities and properties are affected by the specificity of each modelling process, modified by the context of production and use of modelling processes. The insights that models provide about a specific phenomena can be of different nature; the goal of this issue is to show in practice how different modelling approaches operate in relation both to their contexts of production and use and in relation to each other.

Already at project proposal stage, comparisons and exchange across disciplines, within and beyond the humanities and cultural studies, were deemed crucial to establish an integrative concept of modelling within the project and inform an understanding of what draw us towards (digital) modelling, of how and what can we learn by modelling, and of how modelling changes our perceptions and conceptualisations.

Indeed, while rooted in the disciplinary context of DH, some of the project research activities examined the role of modelling and models in designing ways of knowing (epistemologies) and being (ontologies) in other selected disciplines. In particular, the workshop on which these proceedings are based was conceived as a means to reach out and benefit from a wide range of disciplines and traditions. Examining the capacity of modelling practices to develop "trading zones" that foster interdisciplinary exchange was paramount to the project's original perspective and goal. The international workshop Thinking in Practice was proposed as a catalyst to achieve this aim.

Scholars who are engaged with modelling or are contributing to the scholarly debate on modelling were invited to participate to the workshop at Wahn Manor House, so that diverse areas of expertise and disciplines were represented. Philosophy, Semiotics, Digital Humanities, Computer Science, Archaeology, Geography, Literary and Intermedia Studies, Psychology, Educational Studies, Classics, Information Studies and Software Engineering were the research areas represented at the workshop. 24 participants attended the two-day interdisciplinary workshop and 13 speakers presented their perspectives and ideas concerning modelling. To facilitate the sharing of ideas in a creative and stimulating way, contributions were framed within a dialogic format which was complemented by guided practical exercises in which participants were asked to reflect upon their own positions in a less conventional yet structured way.

One of the aims of the workshop was to engage in a critical comparison of approaches focusing on modelling rather than models. This included presenting concrete practical modelling exercises as well as theoretical considerations from a number of different disciplines. The comparison had the ultimate objective of opening up the discussion to identify emerging aspects transferrable across disciplines. It was also an aim to challenge our views and modify and enrich them based on exchanges with colleagues from other fields and trained in different traditions, culturally and linguistically as well as disciplinary. Therefore, the concepts of model and modelling that merge from this volume presents very different theoretical and methodological perspectives. The resulting set of papers offers a view on these concepts that supersedes some of the most common assumptions in history and philosophy of science, whereby the manipulation of models is given primary focus. Indeed, one of the objectives of our project was to investigate the creative process of thinking at play in modelling practices, and how the manipulation of models interfaces with other acts of signification and reasoning are often highly facilitated by the use of metaphors. These proceedings are instrumental in presenting a discussion on the use of formal and informal languages in the process of modelling, in particular within research contexts in the humanities, engineering, and computer science.

The organization of this volume reflects the structure and the organization of the workshop itself. To facilitate the interdisciplinary dialogue we asked each participant to address a series of questions and respond by sharing a written "position paper". In addition, each participant was assigned a respondent so as to stimulate further discussion. This format is retained in the papers collected here, whereby each paper is followed by a short summary of questions and answers. The questions circulated to participants in preparation for the event were the following:

a) "What are the main challenges in the language around modelling?"
b) "What is the role of analogy, similarity, visuality, and iconicity in modelling?"
c) "Where would you position modelling on the imaginary axis theory/practice?"
d) "Do you see modelling as a core method in your discipline?"

These questions aimed to integrate theoretical approaches with practical methodologies in the study and application of models and modelling.

The opening of the workshop also followed interactive format. The presentation of the workshop scope and objectives was performed as a dialogue in which themes, aims and participants were narrated and described "as if" from a theatrical stage (see Appendix in this introduction). Arianna and Oyvind, respectively a cat and a fox, set up the context of the workshop including the agenda for the two days, and introduced each participant as well as the group of organisers, explaining the aims and the objectives of the meeting. The dialogue was intended as integrated part of the event by setting the context for a common methodology. It was based on the understanding that in such a multidisciplinary context, it was important to de-academicise the communicative structure and to be open to different languages, modalities and codes of interaction and discussion. Furthermore, the lexicon and metaphors adopted in the "dialogue" reveal the multidimensionality of the concept of model while also explicitly referencing the strengths of each invited participant.

In order to stress the importance of the role of each pair of speaker and respondent, of their exchange and of their cross-disciplinary contributions, each participant received as his or her badge a puzzle piece[9] matching the one of their paired "companion". The joint between the pieces of the puzzle were meant to symbolically represent the articulated composition and complexity characterizing the workshop as a meeting of minds.

To further enhance the exchange and benefit from the encounter amongst participants, we decided to combine the discussion with more playful activities in the form of interactive exercises. The exercises were intended to develop and stabilise each workshop participant's position with respect to the topic been discusses, as well as to grasp the most salient concepts or elements emerging during the paper sessions. To guide this part of the work we used two interrelated metaphors: the ship and the island. Aquatic or maritime as well as terrestrial metaphors were adopted. Indeed, these conceptual metaphors are highly interrelated, particularly in the discourse around research, research investigation, and knowledge organisation. They have developed into commonly accepted models vehiculating, structuring and mapping knowledge in research discourses. They are also key metaphors in DH. For example, the use of the tree metaphor is adopted extensively in the creation of taxonomies and schemes of knowledge and has been taken up as a common way of seeing textual structures, while the use of maritime metaphors such as "navigation" and "net" is central in the discourse around the web more generally. The properties of these metaphors adequately captured the nature of the workshop discussion: the fluid dynamic exchange facilitated at the event; an investigation around modelling as

9 See the contribution of C. Marras (2018) in the Focus section of this volume.

both an analysis of the surface and a plumbing of the ocean depths; the importance of the organization of a ship, where everybody contributes to successful navigation (from the chef to the skipper, from the common sailor to the officers or the mechanic); the centrality of the on-board equipment (many things are needed: food, scientific instruments, etc.); and the differing expertise and roles of the crew. The route of a ship is traced up front, but subsequently adjusted during navigation to cope with the many unforeseen events at sea. The workshop was structured as an expedition, a navigating out to explore the open sea.

Altogether, the present volume reflects particular research interests in current studies of modelling. The contributors have connected their papers to dominant scientific debates around modelling concepts, but at the same time introduced original perspectives compared to the vast literature on the subject. The growth of knowledge, the cross-disciplinarity, the incipient cooperation between approaches and expertise on models and practices of modelling is therefore what is thematized in this issue.

This issue is divided in two parts: section 1 includes the 12 paired peer reviewed papers presented at the workshop, whereas section 2 is a Focus section where specific topics that arose during the workshop are discussed and analyzed. The Focus section complements the Articles section and it is intended to discuss, highlight, and reflect on some of the issues and methodological aspects that emerged from the two-day workshop. It focuses on key issues around modelling (Patrick Sahle, *How to recognize a model when you see one. Or: Claudia Schiffer and climate change*), methodologies and languages (Cristina Marras, *A metaphorical language for modelling*) as well as organizational and logistic aspects (Zoe Schubert and Elli Rehul, *Setting the space: Creating Surroundings for an Interdisciplinary Discourse and Sharing of (Implicit) Knowledge*). Moreover, two contributions are dedicated to the analysis of the concepts and definitions emerging from the papers and discussions as they were recorded using an observational grid. This grid was designed for the workshop and was filled in during the different sessions (Nils Geißler and Michela Tardella, *Observational drawings. From Words to Diagrams.*). An "external" view on the meeting from a participant who were neither a speaker nor an organizer completes the Focus section (Tessa Gengnagel, *The Discourse about Modelling: Observation from a participant*).

The 12 papers of Section 1 were written and shared in draft form as part of the preparation for the workshop and reviewed for the purpose of this publication. Each of them also includes responses based on the workshop discussions. As outlined above, by inviting experts from a variety of disciplines, the project team brought together diverse, complementary and sometimes conflicting theoretical views on and practical experiences with modelling. Some very crucial questions for scholars working on modelling and on what underpins the practice of modelling from an interdisciplinary perspective were asked by

Willard McCarty, a key figure in establishing the foundations for the concept and practice of modelling in DH. In his *Modelling what there is: Ontologising in a Multidimensional World*, McCarty addresses the question of interdisciplinarity in an epistemic and constructive way: "disciplines are not places of arrival, clubs to be joined, identities to assume or platforms of visibility, but starting-points". In *Models, modelling, metaphors and metaphorical thinking – from an educational philosophical view*, his paired speaker, Nina Bonderup Dohn, an expert in education studies and processes of design, presents her view on models within educational research defining models as "instruments for configuration and reconfiguration". She refers to Paul Ricoeur's claim that metaphors and metaphorical thinking overcome the conventional analysis of metaphors inherited from Aristotle, also known as the "substitution model", and see figurative language as the primary vehicle for the disclosure and creation of new forms of meaning.

That models are necessary for thinking is the radical position taken by Barbara Tversky, from the perspective of cognitive psychology. In her *Multiple models. In the Mind and in the World* she takes elements and relations among models in the represented world and map them onto elements and relations in the representing world. Spatial models representing, for instance, gesture rely on more direct and accessible mappings to meaning than language, which bears only arbitrary relations to meaning. Her paired speaker Christina Ljungberg, on the other hand, bringing in her work in the area of iconicity in language and literature, discusses the relationship between modelling, reasoning, and creativity. With examples from picture viewing, map reading, and mental diagrams in verbal language, in *Iconicity in cognition and communication,* she argues that iconicity is essential to reasoning, communication and mutual understanding.

Modelling is ubiquitous in the humanities: the search for patterns and principles, and the links between them, is found in all humanistic disciplines and periods. The debate around this assumption is represented by two papers: *Modelling in the Humanities: Linking patterns to principles* by Rens Bod in which some commonalities between modelling in the humanities and in the sciences are discussed and different modelling strategies and practices explored. In *Modelling in the Digital Humanities: a Research Program?*, Fotis Jannidis focuses on the different research fields were the term modelling is used, under the assumption that is hard to defend that they are all conceptually connected. Jannidis proposes to collect examples of different practices, in order to determine, which have essential communalities.

The specificity of modelling practices in archeology is discussed from a theoretical perspective by Oliver Nakoinz in his *Models and modelling in Archaeology,* where the author stresses the importance of a "trans-disciplinary modeling" framework for archeology, a discipline often challenged by conflicting attitudes towards the creation and use of models.

From his broad and cross-disciplinary perspective and cartographic practices, Gunnar Olsson provides an eclectic excursus in which the dialectic interplay between ethics and aesthetics, two sides of the same coin, guide us throughout his *EVERYTHING IS TRANSLATION (including the art of making new boots out of the old ones)*. A semiotic perspective in the framework of Charles S. Peirce's theory of signs is introduced by his paired speaker Claas Lattmann in *Iconizing the Digital Humanities. Models and modelling from a semiotic perspective*. In this contribution models are considered as icons; the fact that models are not identical to the things they represent (and that they represent only partially) are the true basis for genuine creativity and progress in research.

From the field of engineering and computer science, Giorgio Fotia and Paul Fishwick discuss how modelling represents a core method of investigation in the sciences. Fotia, with his paper *Modelling practices and practices of modelling,* proposes the concept of computing as an instrument for discovery in the sciences and as a useful metaphor to reflect upon when trying to unify the description of the practices of modeling across many different domains. Fishwick, in his original perspective on *Information modelling of the Humanities,* claims that the idea of information and information processing is part and parcel with the humanistic tradition and that written and pictorial languages can be used as basis for formalizing information and models.

Models in computer science and in digital humanities were the focus of Günther Görz, *Some remarks on modelling from a Computer Science perspective* and Francesca Tomasi, *Modelling in the Digital Humanities: Conceptual data models and knowledge organization in the cultural heritage domain*. Görz addresses a key point in his reflection on models and modelling: the distinction between models *of* and models *for*: "One of the basic tasks of computer science is to rewrite models derived from other scientific disciplines so that they can be represented and processed on computers." This makes the practice of modelling in a research software engineering context an inherently interdisciplinary undertaking. Francesca Tomasi sees data models as knowledge organization systems which are at the core of the Digital Humanities domain. In her paper she adopts a multi-dimensional vision: models are seen as processes of abstraction, as interpretations, and as formal languages to implement such abstractions in order to create something processable by a machine.

When taken together, the 12 papers provide an interdisciplinary insight into the relationship between model and modelling. A dense intertextual structure pervades this volume. The reader is invited to follow the threads through the different contextualisations and analyses of models by linking the papers with a broader theoretical approach to modelling with the ones which are case-studies oriented.

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Appendix: The Dialogue

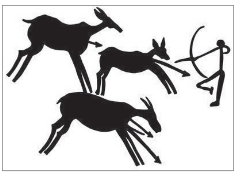
Photo 1 and 2: The Fox and the Cat

The stage is set. A castle, it is called; in reality more of a mansion. A place of illusions, of double addressing and complex references. The site of a theatre museum. A castle in which pizza is served from cardboard boxes. Illusions and fictions. Something pretending to be what it is not, something standing for something else. Models and stories, multiple levels of signs.

Two persons pretending to be what they are not. Gesturing to their demonstrable incapability to be actors, they stand there as objects for the gaze of an audience not yet aware of its composition nor of the rules of the game. Objects trying to take the lead as subjects, trying to mark the setting, using masks and pretence.

They try to de-academize an academic setting, using the memory of the place to bring back what could have been different. Their play was easily seen through. In self defence they made themselves openly vulnerable. A fox. A cat.

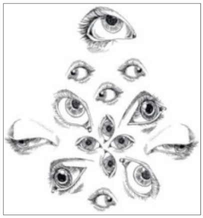
And what is an actor if not a model representing the world view of the author and the stage director? All models, models everywhere; not only the workshop but the whole project is already threatened with a total breakdown into a meaningless all-encompassing concept of models. Even a cave painting is a model. What about the cave itself? Where to start? How to sort out this mess?



Have mercy on them. Give them a voice, let them try to explain.

- Why are we here? What do we expect from you? We will not spend much time on this introduction, but still: where can we start?
- From the beginning perhaps? From where the project came to be?
- Yes. We kept talking about modelling, we talked a lot, both of us, but always came back to modelling, like the centre of a rosetta. We did not just talk, we were also inspired by reading works of wise people in Digital Humanities.
- Like Willard, your PhD supervisor and my missed teacher.

- Yes, him of course. The word was polysemous but we were not scared. Maybe a bit too cocky sometimes. And with fixations, like jotting things down, creating short texts describing all sorts of weird things. You know.
- We had some ideas about how to juggle slippery concepts like modelling. We had some disagreements too. We saw the Volkswagen Foundation call, the deadline closed in on us and instead of it wooshing by we jotted down something and drew together our dream team. Remember?
- How old do you think I am? Of course I remember. Cristina and Patrick.
- And they said yes! We knew already then that they would go for the best research assistants, hiring Michela, Nils, and Julia.

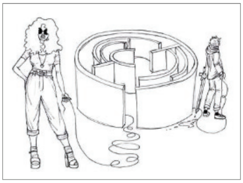


- Well, how could they say no to you? We also got a lot of support from my colleagues in Passau and Jonas came here to take part in the fun. What we did not know then was that Zoe and Elli would make it all even better. Thinking with more eyes was what we needed in order to expand our horizons and see in multiple dimensions.
- What we did not yet know was that the Volkswagen Foundation would decide to fund our project! Thanks Vera!
- We were ambitious and uncertain; we still are, I guess we will always be, but we also knew it was worth the challenge. Digging into what people mean and meant by modelling and how they use it, both the words and the activity. Draw some lines to follow, finding a way. Our way.
- Yes and going beyond Digital Humanities, peeping out at the vastness of the open sea. Where to start?

- We knew we could stay in the *mare nostrum* more or less comfortably and that's why the project has case studies on modelling texts and modelling events – the case studies will be challenging but we wanted to make sure we could draw from others beyond the team and beyond Digital Humanities.
- To be frank the interdisciplinary workshop idea was to seek inspiration but also to make sure we had stars to orient by when we sail out to see coastlines we did not yet know. So much new. So much happening. So much to understand. It takes a village to bring up a researcher.
- We tried to be brave. We wanted to catch a glimpse of the same feeling we had when reading Gunnar's book *Abysmal*.
- Yes, grounded but ready to fly. You can't be grounded without references and you can't fly or navigate without pointing ahead.
- Thanks to an important team effort we managed to get people here that could ground us in different ways; whether in an archaeological pit holding Oliver's hand or in a gesture following Barbara's route descriptions –

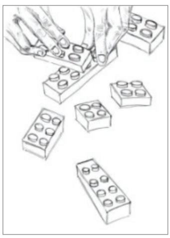
which in many ways stand between texts and maps, as manuscripts in general stand between the spatial and the textual.

- Indeed, and like Anton Ego in *Ratatouille*, all we want is some perspective. Rens can give us some looking back, forward and sideways at the history of the Humanities. Fotis will unflatten texts, building a statistics of wonders.



- Günther by taking us down and up in the labyrinths where artificial intelligence meets computer sciences through the practice of museum curators using WissKI.
- Giorgio would weave the threads where soft and hard sciences are made of the same wool.

- I don't like hard and soft but wool is cool. Paul knows how to make modelling of artworks talk with computing. Francesca spins the wheel of knowledge representation.
- And Nina talks to and with people, young people, those who will come after us and for whom modelling and design could make a difference in life. A difference for life to come. A part of their cultural capital if we take our responsibilities seriously.
- Yes, because ultimately modelling for us is a way or many ways of making sense. Understanding modelling is part of a diverse cultural literacy one should master, as citizen in a democracy. Show the kids they can model – and then we can learn from playing with models together.
- Claas and Christina will dare to hold some icons, a special type of icon via which we make sense of the world.
- (If I understand what an icon is tomorrow night I will be happy – and probably a bit sad too. If not, it is not their fault). Make sense of the world? Or the many worlds?
- Whatever helps us reason, playing with the blocks, building new things, making sense of the old ones.

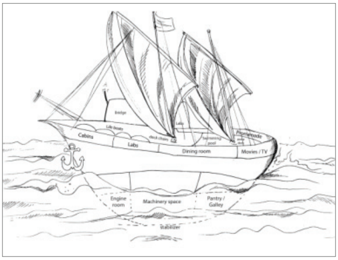


- I don't remember where it came from exactly but in Krakow we realized the modelling qualities of the Danish wonder tool for thinking with your hands, playing with brick models. [pause] We finally got to our Lego then!
- Well, Lego is not to be talked about, and workshops are not about introductions. It is about time.

Turning to the audience the fox expresses the hope that they have given at least a vague idea why each and every one in the room are invited.

The false modesty of the false animals stays until the end.

Leaving the pseudo-fiction they move over to their appointed roles in life and break the spell through a final short academic presentation of the project "Modelling between digital and humanities: Thinking in practice," its aims, participants, and methodology.



Through an intense two-day agenda with formal and informal talks, with exercises and shared meals, the specific setting of this event will release a shared potential among and between the participants. This, at least, is the hope of the organizers. The dream of the organizers. What the organizers need in order to find a way in the chaos of concept explosions.

Look at them, a last glimpse, up there with the silly masks in their hands and their futile hopes for clarity. Have mercy on them. Try to help them. Give them your best and maybe they will be able to walk around and across the abysses towards the unknown land of their dreams.

Historical Social Research
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HSR Supplement 31

Contributions

Modelling What There Is: Ontologising in a Multidimensional World

Willard McCarty *

Abstract: *»Modellieren was ist: Ontologisierung in einer multidimensionalen Welt«*. The incursion of digital computing machinery into the public sphere and the return of "ontology" from philosophical exile occurred almost simultaneously, circa 1948. In this essay I ask, what do the modelling machine and philosophers' irreconcilable accounts of "what there is" have to do with each other? Are the ontological pluralism of the former and the multi-centric multi-naturalism of the latter kin? If so, then recent anthropology has much to say to digital humanities.

Keywords: Modelling, ontology, anthropology, multidimensionality, semantic stretch.

> [T]he universe has always appeared to the natural mind as a kind of enigma of which the key must be sought in the shape of some illuminating or power-bringing word or name. That word names the universe's principle, and to possess it is after a fashion to possess the universe itself. "God", "Matter", "Reason", "the Absolute", "Energy", are so many solving names. You can rest when you have them…. But if you follow the pragmatic method, you cannot look on any such word as closing your quest…. [Each word] appears less as a solution… than as a program for more work …. (William James, Pragmatism 1907)

> The worlds in which different societies live are distinct worlds, not merely the same world with different labels attached. (Edward Sapir, The status of linguistics as a science 1929)

> The only way you can catch yourself in the act of reflecting on yourself is by becoming another self – a self which, when it looks down on your reflecting self, will not be included in the reflection. If you want to understand yourself better, you always have to keep on the move. (Jonathan Rée, I See a Voice 1999)

1. A Mid Twentieth Century Co-Occurence

These days, for perfectly obvious reasons, some of us find ourselves telling a Spenglerian *Untergang des Abendlandes*. The evening news confirms that we are all going to hell in a handbasket. But when I look around what I see is an abundance of compelling scholarship in many disciplines, scholarship that

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beckons us to interconnect our own work with it and to connect both to the world we live in. The connections to be made are reciprocal and recursive: we give that others may give back, *do ut des*, again and again in a cycle that changes both.

Here my aim is more modest than such a large project would suggest but still indicative of the benefits. My aim is to suggest – I can do no more than that – some of what might result from growing connections with anthropology and related disciplines. Anthropologists, you may know, have been interested in doing the reverse since at least 1962 (Hymes 1965) and were thinking along similar lines from the early 1940s (Heims 1991, chap. 2). Today both sides have much more to offer each other than was the case then.

My story begins with a curious mid-twentieth century co-occurrence in the Anglo-American world: of the digital computer (which must be told what there is) and of the return from philosophical exile of ontology (the study of what there is – or, as Ian Hacking says (2002, 2), of "whatever we individuate and allow ourselves to talk about").[1] Stumbling on this co-occurrence led me to wonder how the two co-occurrents might be connected beyond computer scientists' adoption of the term in the late 1970s.[2] You may know that thirty years earlier, just as the public was becoming aware of computers, philosopher Willard Van Orman Quine began giving serious attention not just to ontology but to ontologies in the plural.[3] (In Germany the co-occurrence happened earlier, with Martin Heidegger's *Sein und Zeit* in 1927 and Konrad Zuse's Z-series machines from ca. 1935, a year before Turing's foundational paper.[4]) I asked myself, what might there be in these co-occurrences to help us explain them? But then I noticed something else: the rather dramatic and fruitful career, seeded by Quine, that ontology has taken in theoretical anthropology and related disciplines for the last few decades. So my question became also this: what

[1] A convenient date for the first public exhibition of a large-scale digital computer is the launch of the Selective Sequence Electronic Calculator (SSEC) at IBM World Headquarters (New York) in 1948, visible from street-level until 1952 (McCarty 2011, viii). For ontology see note 3.

[2] For early examples see Kosslyn 1978 (drawing *inter* alia on Goodman 1968) and McCarthy 1980, Alexander et al 1986. Formal definition came with Gruber 1995. See also Gruber 2009, Sowa 2000 (51-131) and Zúñiga 2001. For related activities in Natural Language Processing see e.g. Margaret Masterman's work in the 1950s and 1960s (Priss and Old 2009; Sowa 2010 [245-50]); for database design see Sølvberg 1979; Ramsay 2004 (195).

[3] See Quine 1948, (1953) 1961 (his note on "Identity, ostension, and hypothesis", p. 169, in particular), (1960) 2013 and 1969. For the status of ontology at the time see Feibleman 1949.

[4] At the very beginning of *Sein und Zeit* ([1927] 2001, §3) Heidegger makes a distinction between ontological (Being as such) and ontic (regional or specific Being, i.e. delimited and implicitly temporal, as studied in the sciences); see Steiner 1978 (79-80). For Zuse's development of his stored-program computer see Zuse (1993) 2007 (chap. 3). Heidegger's work became known in Anglophone computer science with Dreyfus 1972 and important in that discipline thanks to Winograd and Flores 1987.

might we learn about the creative potential of digital machines from the scholars of human historical and contemporary alterity?

Nothing in the literature suggests that computer scientists took much notice of philosophy when they started talking about ontology. Perhaps they thought they didn't need to, since ontology is obviously fundamental to computing machinery: after all, to do any useful work the machine must be given a model of what there is (Smith 1985). But the complexity of the world and limitations of time constrain any implementable ontology to be a version of the domain to which it applies, that is, to be an ontology, one of many. Hence the implicit, more specific and possibly important connection between the digital machine and both Quine's and Heidegger's pluralisation.

2. The Popularity of "Model", Many Ontologies and Cosmological Change

To get further with this, let me take a different tack. When we think about models carefully, as Nelson Goodman did in *Languages of Art* (1968), we can become quite annoyed, as he did, at the ungovernable, viral appeal of the word "model". For us its sloppy use makes its specifically computational sense difficult to pick out; in consequence, we are apt to miss what is genuinely new and so have no convincing answer other than "more, faster" to rightfully skeptical colleagues. But its popularity is an inescapable fact, I realised. So I started to ask, *why* is it so popular? Was the invention of the digital machine a like response, as the coordinated surge of word and thing would suggest? [Figure 1]. Might the same be true for "ontology"? What can we learn from that? What are they responses to? Answers aren't as obvious as may seem: Plato's *Symposium* teaches that we tend to go for what is achingly present in its absence, and so want, and thus desire. Rather than go for a quick dismissal by reference to technological determinism, *pure* coincidence or the fog of a *Zeitgeist*, I wondered if we might be able to identify a Foucauldian "historical *a priori*"[5] – or, to paraphrase Jonathan Rée, that metaphysical notion which, in the middle of the last century, infiltrated ordinary common sense and became a real force in the world (1999, 382).

Consider, for example, Quine's argument that translation is inevitably indeterminate 2013 [1960] chap. 2), from which he concludes that we can do no better than many incompatible stock-takings of the world's goods. Put that next to Quine's friend and reader Thomas Kuhn's argument two years later in *The*

[5] The phrase is from Georges Canguilhem's review of his former student Michel Foucault's *Les mots et le choses* (1966) in Canguilhem 2005/1967, 90; quoted and discussed in Hacking 2002, 5.

Structure of Scientific Revolutions (2012 [1962]) for the inevitability of successive, incompatible, indeed incommensurable paradigms. Consider also my favourite example of a clarion-call within digital humanities: the American literary critic Louis Milic's short article, published four years after *Structure*, in which he wrote that, "We are still not thinking of the computer as anything but a myriad of clerks or assistants in one convenient console" (and I would go so far as to say "a myriad of *servants*", since for us their far quicker, less intrusive and better service is so discrete as to be all but invisible). "The true nature of the machine is unknown to us…", he went on to say (and I would add, unknown because this "nature" is not natural, not a given, but an emergent recursive co-creation of human and machine). Milic saw, as he said, that "Its intelligence and ours must be made complementary….", and so implied the crucial beyond-the-Turing-Test question of what we take intelligence to be. He went on: "Thinking in a new way is not an easy accomplishment. It means", he said, "*reorientation of all the coordinates of our existence*" (1966, 4-5, my emphasis). It means, in other words, a cosmological reconfiguration. He called his brief article, "The next step". It was, I like to point out, the first article in the first issue of the first journal in digital humanities. I don't think we've taken that step yet.

3. The "Ontological Turn" in Anthropology

I intended no causal implications when I said that Quine seeded later developments in anthropology, though his thought-seed did germinate there. What he actually did, on record, was to draw an analogy between the ontologising philosopher and a fictional anthropological linguist attempting to translate an imagined native's exclamation at the sight of a rabbit (2013 [1960], 25ff.). Such was and is the field anthropologist's dilemma, the core scenario to which some anthropologists have responded by making what has been called "the ontological turn", away from the epistemological angst Quine depicted to something rather new.[6] Commenting on Eduardo Kohn's *How Forests Think: Toward an Anthropology beyond the Human* (2013), for example, Philippe Descola refers to

> [the] general predicament that some of us… find ourselves enmeshed in. To put it simply, the project of repopulating the social sciences with nonhuman beings, and thus of shifting the focus… toward the interactions of humans with (and between) animals, plants, physical processes, artifacts, images, and other forms of beings… (2014)

[6] Increasingly noisy since Henare, Holbraad and Wastell identified "a quiet revolution" and applied the term "ontological turn" to it (2007, 1, 7).

Modelling (we might say) everywhere, of everything, by every being with agency.

The arguments quickly become complex, intricate, difficult. I can only present a sliver. Almira Salmond's helpful overview in the journal *Hau* sorts the enthusiastic confusion this turn has become into "three ethnographic strategies for addressing ontological alterity" (2014): Tim Ingold's, Descola's and the one she favours, which for want of space is my sole focus here. She calls it "recursive" because it draws recursively, transformatively on "the imaginative powers of the… peoples and collectives" whom anthropology proposes to explain.[7] Its leading proponent, Eduardo Viveiros de Castro, defines it in stark contrast to what he calls "our modern cosmological vulgate": the multiculturalist supposition of "a single world or nature… around which different partial cultural views orbit" (2010, 329). This vulgate sounds pleasingly liberal and democratic. Look closely, he argues, and the single world it supposes turns out to be our world universalised. In other words, take a step back and this world begins to look very much like Michel Foucault's invocation of Jeremy Bentham's panopticon.[8] In the late eighteenth century Bentham designed a cylindrical prison with a central watch-tower from which all inmates could be secretly observed. Because no inmate could know when he was being watched, the panopticon induced "the sentiment of an invisible omniscience"[9] – a crippling, economical god's-eye view. Hence the predicament of those entrapped by their very visibility, as Foucault has said, and thus Viveiros de Castro's metaphor for the colonising grip of that panoptic cosmological vulgate.

4. The Multidimensionality of the Real and Our "Next Step"

Ontology had to change before the turn in anthropology could be made, from elaboration of a "great chain of being" to a probing which reveals multiple ontologies.[10] The modelling machine, working through many disciplines, has undoubtedly been an influential part of this change, so also the viral spread of the term "model". Remarkably, throughout the panic of relativism in the "science wars",[11] modelling and the many ontologies it makes operational have diversified not destroyed the idea of the real. The anthropologists I have quoted

7 Viveiros de Castro 2014 [2009], 40.

8 Foucault, "Panopticism", in Foucault 1995 [1975], 195-228; plate 3 shows Bentham's design). See Bentham1995.

9 A widely quoted phrase, not in Bentham's works, often attributed to an anonymous architect. See Nugent 2011; Lyon 2006.

10 Lovejoy 2001 [1936]; see also Lovejoy 1909.

11 Hacking 1999; Geertz 1984.

have responded by taking "the enemy's point of view" seriously – Viveiros de Castro's phrase 1992 [1986] – as a recursive instrument of disciplinary self-redefinition. Such recursion is no stranger to modelling. Ancient historian and anthropological fellow-traveller G. E. R. Lloyd has used his half-century of meticulous comparative analyses of ancient Greek and Chinese thought to draw out the "multidimensionality" of the real and to show the "semantic stretch" it requires of us.[12] We might call this the agile modelling of an endlessly faceted world. Thirty-five years ago Ian Hacking, in *Representing and Intervening* (1983), argued cogently that new things become real by means of manipulatory experimental modelling. In his essay "Historical Ontology", he has asked, echoing Foucault: "if we are concerned with the coming into being of the very possibility of some objects, what is that if not historical?" What does such reasoning lead to if not specific, local ontologies, "molded in time"?[13]

What is to be done with these anthropological, historical and philosophical inflections of modelling gone viral – with the possibilities they suggest and the demanding help they offer for growing nascent digital humanities into one of the *literae humaniores*? That's the question I struggle with. Half a century on from Louis Milic's "The Next Step" I wonder what we can say his cosmological reconfiguration would entail if we took it seriously by taking on the anthropologists' challenge. To use Clifford Geertz's terms, it would mean something far beyond the mimetic "modelling *of*" real-world data, beyond also "modelling *for*" objects that begin as more or less definite ideas and aim at concrete realisation.[14] Both of these will, of course, remain valuable things to do. But they are hardly sufficient for a computing *of* as well as *in* the interpretative disciplines. (Let us be done with the crippling fright of the technoscience which makes our beloved machine possible and with the equally damaging ignorance of social thought, and so call these disciplines the *human sciences*.)

What I think taking Milic's next step might lead to most immediately is a concerted, experimental, hardware-actualised enquiry into what we mean by "intelligence", by "reason", by "cognition" – recursively involving *the machine's point of view with our own as both develop in interaction with each other*. This is not the already well developed programme to demonstrate that cognition is computational, rather to find out through a back-and-forth conversation *what it is*.[15] It would mean enquiring into the machine's cosmology, as it is now, as it could become. This enquiry would mean, to paraphrase Viveiros

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[12] Lloyd 2015, 5. See Inwood and McCarty 2010, contributions to which embrace all three of Salmond's ethnographic approaches to ontology. For a summary of Lloyd's work, <https://en.wikipedia.org/wiki/G._E._R._Lloyd> (Accessed December 19, 2016).

[13] Hacking 2002, 2, 4; Foucault 1984. See also Lovejoy 1909.

[14] For a discussion see McCarty 2013 [2005], 24; referring to Geertz 1993 [1973], 93.

[15] Yes, some of this goes on in the cognitive sciences, but we in the humanities have not included ourselves, nor have these sciences looked often to the humanities for more than window-dressing.

de Castro, treating ideas indigenous to digital hardware as concepts to think with, then following the consequences, defining the range of possibilities these concepts presuppose, the conceptual persona they make possible, the reality they delimit (2014, 187). This is in no way to disrespect the Amazonians and the others from whom Viveiros de Castro and colleagues have learned so much. It is, rather, to ask if we can learn from these anthropologists in turn what it means to pull oneself away from the narcissistic self-entrapment that Joseph Weizenbaum discovered in the mid-1960s when users of his conversational program *Eliza* mistook it for their confessor.[16] It is to ask whether the ontological turn in the anthropological sense has taken hold in digital humanities.

Is it not nascent in what the scholar-programmer already does, most when designing, building and refining simulations? Elsewhere I have argued that the great lesson to be learned from simulation – which is modelling turned loose to go where it can – is that it shows computing to be just such a producer of fiction: an instrument not so much for nailing down facts (although it can do that) but for imagining them, acting them out, solidifying them, in some cases giving us a new (tentative) reality to probe (McCarty 2018). I know of no better example of this than John Wall's simulation of John Donne's Gunpowder Day sermon in 1622 as it might have been delivered from the long-vanished Paul's Cross preaching station adjacent to the medieval St Paul's, which the Great Fire of London destroyed in 1666. With his *Virtual Paul's Cross* Wall explores "what we are doing when we believe we have discovered, from our experience with a digital environment, things about past events that are not documented by traditional sources" (2016,283). That's a cliff-edge, inviting flight, a fiction (to paraphrase Viveiros de Castro) that is historiographical, but historiography that is not fictional: a digital machine's perspective on the sermon preached on a semi-fictional occasion by a semi-fictional John Donne from a semi-fictional Paul's Cross in a semi-fictional space to a semi-fictional crowd. Ironically we have very good reason to think that it is a better, more truthful fiction than we get by pretending that Donne's published words, which he wrote down sometime later from the notes he used while preaching, are the real sermon.

In 1962 Cambridge linguist Margaret Masterman proposed that the computer could become a "telescope of the mind", changing, as the early telescope did, our whole conception of the world (1962, 38-9). Some toss this off. But is the instrument as unproblematic as her metaphor seems to imply? To echo Hacking (1983, 186-209), do we *see* through, or see *through*, a telescope? Today (just as in microscopy) optoelectronics interpose a hermeneutic blackbox between the eye and its object, complicating – but not essentially altering –

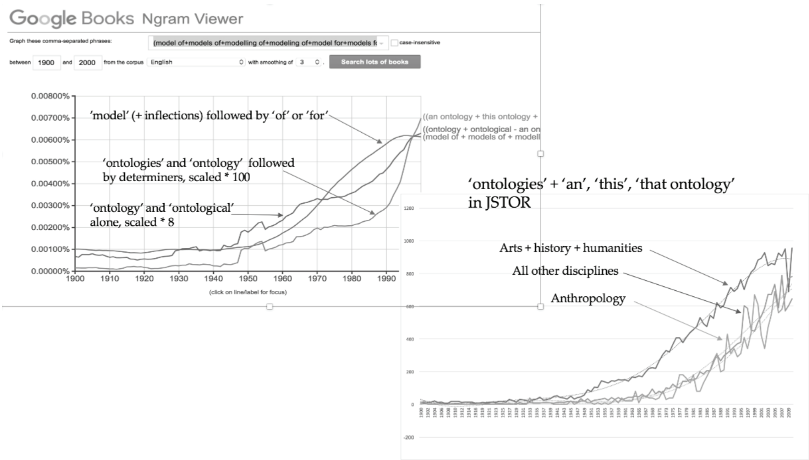
[16] See esp. the introduction to Weizenbaum 1976. Note that according to its author, *Cannibal Metaphysics* is a commentary on an unwritten, fictional book entitled *Anti-Narcissus: Anthropology as a Minor Science* (Viveiros de Castro 2014 [2009], 39).

the philosopher's question. For when Galileo looked through his *occhialino* much of what he saw had been seen before, but the differences were enough to make "what was" "momentarily mutable", stuff of the eye reshaped by his mind into "a compelling argument for Copernicanism".[17]

Disciplines, I like to say, are not places of arrival, clubs to be joined, identities to assume or platforms of visibility, but starting-points. So the question is: where from here? There are many maps.

5. Figure

Figure 1



[17] Thanks to Crystal Hall (Bowdoin) for the commentary on Galileo, in private e-mail, 6/1/17. The literature is extensive; see esp. Lipking 2014; Biagioli 2006, chap. 2.

6. Discussion

NBD: Nina Bonderup Dorn
RB: Rens Bod
GO: Gunnar Olsson
FJ: Fotis Jannidis
WM: Willard McCarty

In her dedicated response NBD singled out the alterity of worlds, especially its connection with the concept of situated knowledge in her own paper. She questioned the implications of "ontological turn", asking whether the change is not so much a rejection of epistemological concerns but a product of them and a shift of emphasis. WM agreed, noting the meandering of "turns", now this way, now that, common in academic disciplines, each turn attempting to correct for prior deficiencies. NBD wanted to know what is "the machine's point of view"? WM responded by referring to the mediation enforced by the absolute consistency and complete explicitness of the digital medium and to the combinatorial negotiation implicit in modelling. He argued again for the crucial importance of binary logic on the one hand and imaginative play against that foil on the other.

RB noted that the fictionalizing trajectory of computational simulation, as in the example of the *Virtual Paul's Cross*, is not yet accepted in the humanities. WM pointed to the mistaken belief that the computer is a fact-and-proof machine, a "knowledge-jukebox", and advocated strong emphasis on the machine as an instrument of the imagination. RB mentioned the corrosive effects of simulation on mind/body dualism.

GO, following up on NBD's point about the "ontological turn", offered the arresting counter-metaphor of epistemological and ontological concerns as diachronic intertwined strands, each dependent on the other.

FJ, finally, asked what possibly we can mean by using such words as "intelligence" and "perspective" when talking about machines. He asked if such talk is guilty of a category error. WM thought that the development and adoption of digital machinery was eroding such categorical distinctions, that drawing such lines has a long history of being redrawn to save outmoded ideas of the human. He may have quoted Evelyn Fox Keller, to the effect that asking if a product of computational biology is alive is beginning to look like an historical rather than a philosophical question. And he may have added that "intelligence" no longer looks like a single benchmark.

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Models, Modelling, Metaphors and Metaphorical Thinking – From an Educational Philosophical View

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Abstract: *»Modelle, Modellierung, Metaphern und metaphorisches Denken - Aus einer pädagogisch-philosophischen Sicht«*. In this contribution, I present my view of models and metaphors within educational research, very broadly speaking. I start out by articulating my educational philosophical perspective as a form of applied philosophy. Inspired by Ricœur, I then define models as "instruments for configuration and reconfiguration". I argue that metaphors and metaphorical thinking are more basic than models and modelling. The former can guide reasoning in a holistic, heuristic manner. The latter can be used analytically to develop the initial metaphorical similarity into articulated analogies. Models and metaphors may be deployed explicitly and consciously but may also (mis)lead cognition through implicit structuring of thinking. I proceed to give examples of the roles which models and metaphors have within different areas of (research in) education, teaching, and learning. One example is the explicit development of design patterns; another is implicit adherence to either an acquisition metaphor or a participation metaphor of learning. Towards the end, I provide tentative answers to three questions posed by my discussion pair, Willard McCarty, concerning 1) computer modelling, 2) open-endedness of models and metaphors, and 3) situated knowledge and relativism.

Keywords: Models, metaphors, epistemology, learning, educational research, design patterns.

1. Introduction

In this article, I shall present my view of models and metaphors within educational research, very broadly speaking. I shall start out by articulating the perspective and background from which I come and the type of questions I focus on. I explicate my understanding of "model" and "metaphor" – and their relationship – and proceed to give examples of the roles which models and metaphors have within different areas of (research in) education, teaching, and learning. I thus take on the following questions:

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- Do you have a preferred definition of models and/or modelling?
- What is the relation between modelling and reasoning?
- What is the role of analogy and similarity in modelling?
- Do you see modelling as a core method in your discipline?

The perspective and background from which I approach models and metaphors is that of educational philosophy, with a particular focus on epistemological questions concerning knowledge and learning. I practice educational philosophy as a form of "applied philosophy", *i.e.* a discipline, where philosophy is put to use within other areas of education research[1]. I bridge epistemology and learning theory, and do so both theoretically and in terms of practical pedagogy. It is thus a defining characteristic of my research that I combine philosophical inquiry into the nature and requirements of knowledge and education with the conduct and analysis of empirical investigations of learning practices inside and outside of schools. On this background, querying the significance of models and metaphors as formal and informal reasoning strategies for me concretizes to questions like the following: What role do models, modelling, metaphors and metaphorical thinking play in (research on) educational design? What role do I as an educational philosopher see them as playing in teaching and learning, and in the *conceptualization* of teaching and learning – in research and practice? What role do I as an epistemologist understand them as having in reasoning and cognition in general?

2. Basic Definition of Models – Preferred Definition

Ricœur, following Hesse, defines a model as "an instrument of redescription", explaining that "the model is essentially a heuristic instrument that seeks, by means of fiction, to break down an inadequate interpretation and to lay the way for a new, more adequate interpretation" (Ricœur 2003 [1975], 283). He further claims that models have metaphoric reference, in that, by use of the model "Things themselves are 'seen as'; they are identified… with the descriptive character of the model." (Ricœur 2003 [1975], 287). This fundamental relationship between models and metaphors, that models draw on a metaphorical "seeing as", is central to my approach to models. However, I follow Lakoff and Johnson (1999, 1980; Johnson 1987) in viewing metaphorical understanding, not the linguistic expression of it, as primary. Furthermore, I take models to be grounded in metaphorical "seeing as", rather than the other way around, and in contrast to the position – suggested by Ricœur with Black (Ricœur 2003

[1] I have explicated my view of 'applied philosophy' as a 'philosophizing with' in Dohn (2011b). A collection of articles articulating and engaging in this type of applied philosophy is found in my Professorial Thesis (Habilitation in German) (Dohn 2017).

[1975], 283) – that metaphors and models play analogous roles, each within its own field (poetics versus science): On my view, metaphorical "seeing as" is a holistic coupling of fields where the one is understood "in the light of" the other and where the implicitly postulated resemblance between the fields is as much a result of the "seeing as" as it is a prerequisite to it. Models expand and articulate this holistic coupling into more concrete form, clarifying the resemblance, at once aligning and restricting it. This is done by explicating the resemblance as an analogy between the fields where traits from the one correspond (most often one-to-one) to traits within the other. Models thus – for good and bad – lead thinking along a much more clearly demarcated route than the holistic imaginative metaphorical coupling itself. "Modelling" refers to the process of explicating the holistic coupling as analogy. Paradigmatic examples of models are material or digital configurations/visualizations, mental schematizations, scripts, and theoretical representations. As they are grounded in metaphorical "seeing as" understood not as (first and foremost) linguistic expression, but as understanding of the one field "in the light" or "through the lens" of the other, the basis of at least the former three are not necessarily linguistically articulated. Their explication into analogy will obviously involve linguistic representation and further conceptualization, though. Nonetheless, Ricœur's characterization of models as "redescription" accords too much significance to this linguistic articulation process. Likewise, material and digital models typically provide epistemic affordances through the visualization of relationships between aspects, but Ricœur's terminology easily misleads one to neglect visualization and its potentials. Defining models as "instruments for configuration and reconfiguration" appears more appropriate.

This constitutes my answer to the first question above, i.e. of a preferred definition of models and/or modelling. It also indicates my overall take on the second and third questions, i.e. which role I as an epistemologist understand models, modelling, metaphors and metaphorical thinking to have in reasoning and cognition, and what role analogy and similarity play in modelling: Metaphors and metaphorical thinking are more basic than models and modelling. They can guide reasoning in a holistic, heuristic manner, where the similarity postulated by the metaphor is to some extent configured by the metaphor itself. Models can be used analytically to gain insights based on developing the initial metaphorical similarity into articulated analogies. To this I should add that models and metaphors may be deployed explicitly and consciously but may also (mis)lead cognition through implicit structuring of thinking.

In the following, I turn to the more specific questions of the role of models and metaphors within education and educational research, including educational design. Space limitations bar an exhaustive overview, but I shall provide some indicative examples, which between them illustrate both explicit and implicit uses.

3. Role of Models and Metaphors in (Research on) Educational Design

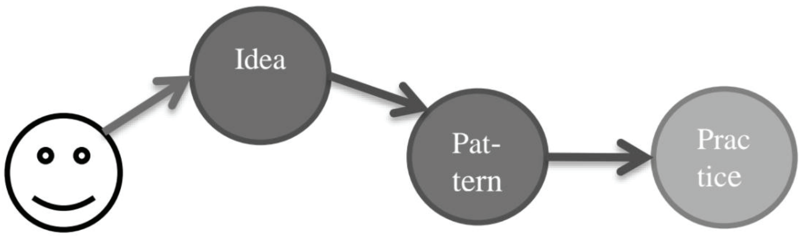
Educational design may be defined as the organization of learning resources and activities to support learners in attaining learning objectives (implicitly or explicitly defined). Educational design is carried out by teachers, course planners, educational developers etc. That is, educational design is not itself research. However, research is undertaken with, for, and on educational design, *e.g.* to develop and test design principles, investigate learning theoretical questions, or test hypotheses on knowing, motivation, collaborative learning etc. Models and metaphors – and modelling and metaphorical thinking – are deployed consciously in educational design, but also play significant roles at a more implicit, unreflected and unacknowledged level, as structuring resources of thinking.

One form of explicit, conscious deployment is constituted by the development, investigation and subsequent utilization of *design patterns* to organize teaching and learning activities in a structured way (Carvalho and Goodyear 2014; Goodyear 2005; Mor et al. 2014). The concept of design patterns was originally developed by Alexander in the context of architecture to deal with recurring problems in a uniform, yet flexible way (Alexander et al. 1977). Design patterns provide a core solution (the pattern) which can be used flexibly in the diverging multitude of situations where the problem is experienced. Within educational design, design patterns constitute models of students' and teachers' activities (design elements), aimed at a particular goal (*e.g.* facilitation of reflection or development of problem solving skills), following learning-theoretically informed principles (design principles) within an overall frame such as a lesson, a test, a lab experiment or study time between lessons. Examples of design patterns are "the interactive lecture" for learner-centered learning (Mor et al. 2014, chap. 1.2.2) and "try once, refine once" for learning through assessment (Mor et al. 2014, chap. 4.2.7). Related to this approach, again involving explicit, conscious use of models, is the development and application of *personas* in the design of courses or educational programmes: A persona is a fictional but realistic character, representative of a group of those users one is designing for, in this case potential participants in the course or programme. Typically, several personas will be developed based on user studies. Between them, the personas should cover the range of different user groups. The advantage of this use of models is that it is much easier for course or programme developers to imagine and take into account learners' (diverging) goals, priorities, attitudes and behavior when they have realistic personalized characters to think from. Potential conflicts between learners may also be foreseen and counteracted in the design.

The development of *design patterns* and *personas* is becoming widespread within educational design. In this sense, this type of modelling is increasingly viewed as a core method within this field (last question above). The scientific adequacy of the method is documented, but is still being researched.

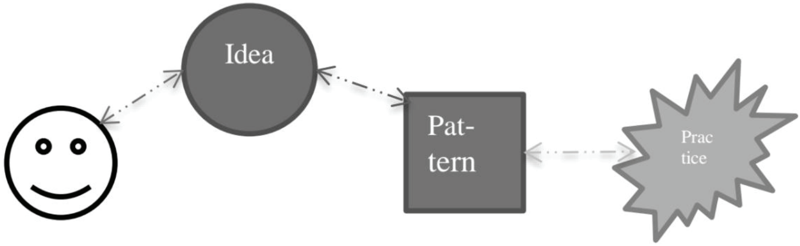
An example of a more implicit use of a model is the understanding – discernable from educationalists' practice – of the implementation process involved in realizing design patterns or "best practice" examples in concrete educational settings. This implicit model is shown in Figure 1. The gist of it is that implementation is a "plug-and-play" process, *i.e.* that there are no essential changes taking place between initial idea, design pattern and actual practice. The initial idea is articulated (becoming clearer but "essentially" staying the same) and then put to use (presupposing predictability of practice "on all essential counts") (Dohn and Hansen 2016).

Figure 1: Implicit Understanding of Design Pattern Implementation Process



However, this is a very simplistic understanding that is not representative of actual implementation processes. There are significant transformational processes involved in articulating an idea and convincing others of its viability (idea → pattern) and likewise in the actual enactment of the pattern in practice (pattern → practice). As argued by Wenger, a design comes into emergent being in the concrete realization which people give it within their specific communities of practices in attunement to and adaptation of already existing routines and participation patterns: "[P]ractice cannot be the result of design, but instead constitutes a response to design" (Wenger 1998, 233). The implementation process is thus more adequately depicted as a "messy", iterative realization process, subject to influence by unforeseen aspects, and therefore not strictly predictable and certainly not linear (Figure 2).

Figure 2: Actual Design Pattern Implementation Process

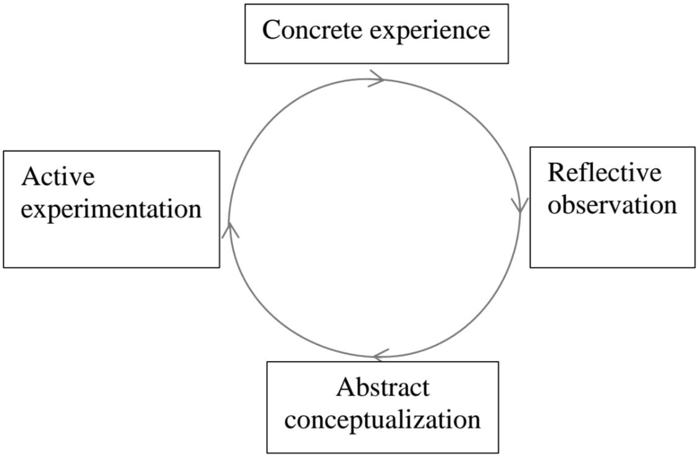


Neglecting the complexities of the implementation process, *i.e.* implicit adherence to the model in Figure 1, is highly problematic, on the verge of being detrimental to learners' learning: It amounts to ignoring the learners' differing uptakes of and approaches to the design pattern as well as the variance in social relationships and interaction patterns across classes/groups of learners. Put bluntly, activities which have been successful in one class may fail totally in other classes.

4. Role of Models and Metaphors in (Conceptualizations) of Teaching and Learning – In Research and Practice

Following design patterns or best practice scripts is one way in which models are put to use within teaching and learning. Conceptualizations of learning and the deployment of these conceptualizations in teaching and learning activities is another. One such example is Kolb's model (Figure 3) of the learning process as a cycle where the learner cognitively moves through processes of concrete experience, reflective observation, abstract conceptualization, and active experimentation – leading again to concrete experience and another spin through the cycle (Kolb 1984).

Figure 3: Kolb's Model of the Learning Process as a Cycle of Cognitive Processes



This model is widely used to argue for the need to engage learners in practical activities beyond reading and writing to allow the experiential and experimental processes to take place. It is also used to structure teaching and learning activities to ensure that learners move through the circle rather than being stuck in one process. A further development of the model is Kolb's claim that learners will have a preference for one (or two) of these learning processes. This leads to a second model with a set of different learning styles consisting of specific combinations of these preferences. Gardner's model of intelligence as comprised of seven different types of intelligence is another example (Gardner 2006), as is the version of learning styles advocated by Dunn and Dunn (1993, 1992). All of these models are put to use within educational practice in the development of teaching and learning activities corresponding to learners' different styles or intelligences–or alternatively, in activities designed to challenge them beyond their preferred style or intelligence. Ideally, this approach has the advantage of customizing learning to each learner, which presumably will heighten their learning outcome. However, there is a clear risk of stigmatizing learners. Likewise, not all disciplines may be learnable through all learning styles/intelligences, just as the competencies required in future jobs may not necessarily match all learning styles or intelligences equally well.

Another example of a model developed in educational research and put to use in educational practice is Hiim and Hippe's relational model intended for pedagogical analysis of learning situations (1993). The model stresses the interrelationship between six elements: student learning outset, framing factors, learning objectives, curricular content, learning process, and evaluation. This model is widely used, at least in the Scandinavian countries, both for analysis of learning situations and for planning them (though the latter is explicitly advised against by Hiim and Hippe).

At a more implicit level, Sfard has shown that two metaphors of learning guide research on learning, namely the metaphor of acquisition and that of participation (Sfard 1998). I have argued that the same metaphors are also embodied in educational and Web 2.0 practices, respectively, and that problems arise when the latter are introduced as learning activities within the former (Dohn 2009b, 2009a).

As a last example I wish to point to an ongoing research project that I am leading, which is sponsored by the Danish Council for Independent Research, Humanities, Grant No. DFF-4180-00062. The title of the project is *Designing for situated knowledge in a world of change*. The overall project aim is to address the challenge posed by two seemingly opposed factors: On the one hand, the need in today's society for people to move frequently between settings and to put their knowledge learnt in one context to use in others. On the other hand, research findings which show knowledge to be situated, *i.e.* as acquiring form and content from the context in which it is learnt (Schön 1983; Lave 1988; Lave and Wenger 1991; Dreyfus and Dreyfus 1986; Dohn 2011a). These research findings imply that knowledge is not easily transferred from one context to another, but needs transformation and resituation. The project has both a philosophical side, aimed at investigating what is involved in the transformation and resituation of knowledge, and a pedagogical side, aimed at developing concrete designs for learning which facilitate learners in learning to transform and resituate knowledge. Our preliminary findings indicate that it is precisely through metaphorical thinking – and to some extent modelling – that learners succeed in putting knowledge to use in new contexts. Metaphorical thinking is involved in the holistic seeing of new situations "as" known ones whilst flexibly attuning to differences between them. Modelling takes place in the form of structure mapping of traits based on the basic metaphorical postulation of resemblance between the situations.

5. Discussion

Articulating a view such as mine within the context of this HSR Supplement's focus on the role of models and modelling in the Digital Humanities of course raises a number of questions. Willard McCarty has posed particularly succinct ones to me. The questions are not easy and I fear that I shall not be able to provide satisfactory answers to them – certainly not within the space allotted to me; perhaps not at all. A few considerations will have to suffice:

Firstly, given the context of Digital Humanities, Willard McCarty very reasonably asks what is special about computer modelling (as opposed to any other kind). Now, posing the question in this way of course presupposes that something *is* special about computer modelling – a presupposition which might well be challenged. I certainly acknowledge – indeed I would advocate – that computer modelling (simulations, visualizations, 3D worlds etc.) permits us to have experiences which would be hard or impossible to come by in the physical world alone, for a number of reasons, including historical, geographical, economical, organizational, physical, and skills-related ones. One example is provided by McCarty in his contribution to this volume where he references John Wall's *Virtual Paul's Cross* (Wall 2016), a computer simulation, made by the Virtual St. Paul's Cathedral Project, which allows one to witness John Donne's sermon for Gunpowder Day, Nov. 5th 1622. Another example is avatar embodiment, which allows one physically impossible bodily experiences such as flying or morphing into animal shapes, potentially stimulating reflections on embodiment itself and its role in cognition and learning (Riis 2016). Yet a third is students' use of simulation programs as part of their academic or professional training, *e.g.* programs emulating chemical reactions or organizational developments. Computers may thus stimulate imagination, facilitate reasoning, and provide us with learning situations in novel ways, potentially leading us to insights which we would otherwise be barred from. Nonetheless, I am not convinced that computer modelling is special in principle, neither epistemologically nor ontologically speaking. Like all other models, computer models require a modeler. This modeler may in some instances be a step removed compared to modelers of physical models, in the sense that s/he works to provide a model which may itself develop over time. Still, computer models depend fundamentally on the imagining of the modeler and on his/her understanding of the domain to be modeled – exactly as do physical models. The basic ontological status of the computer model is thus no different from that of the physical model. Neither is its basic epistemological status: Though it may be harder to foresee the specific epistemic affordances for people engaging with the computer model than for physical models, the dependency of their insights on the scope and direction of the modeler's understanding is fundamentally the same as for physical models.

A second question McCarty raised concerns the degree to which reasoning with metaphors and models can be open-ended. Models, he claims, have an analytical focus, are directed to some end, articulated, and spelled out. Furthermore, he claims, both models and metaphors are analogical, and reasoning by way of metaphors and models thus is reasoning analogically, from a relation between two things we know to a presumed relation between corresponding things (A is to B as C is to D). Therefore, it seems, reasoning by way of models and metaphors cannot really be open-ended.

My answer to this question centers on my disagreement with McCarty about the claim that metaphorical thinking is analogical. I follow Lakoff and Johnson in seeing the dependency between analogy and metaphor as going the other way: Metaphorical thinking is primary: it is a holistic seeing-a-whole-field-as-another-field through the metaphor as "focal point". In this way, metaphorical thinking is in fact open-ended, in that the focal point does not determine the insights to be gleaned by the holistic seeing-as, but sets the outset and domain for them. Analogy builds on the metaphorical, holistic seeing-as, but hones in on certain aspects of the seeing-the-field-as - explicating that "A is to B as C is to D". Thereby it transforms the initial "seeing as" into something more specific, at once enabling and restricting cognition. I agree that modelling is analogical, making it less open-ended than metaphorical reasoning. However, as indicated in my answer to the first question, I do believe that some computer modelling, *e.g.* in the form of 3D simulations, may set the environment for experiences which were not to be foreseen. In this way imagination and insights to be inspired from computer modelling may well be quite open-ended.

A final set of questions from McCarty concerns the ontological implications of my situated view of knowledge. He refers to Donna Haraway (1988), who has argued interestingly about the nature of knowledge as situated, calling at once for a localized embodied epistemology and rejecting both objectivism and relativism. In her words, the essential problem for epistemology and for science

> is how to have *simultaneously* an account of radical historical contingency for all knowledge claims and knowing subjects, a critical practice for recognizing our own 'semiotic technologies' for making meanings, *and* a no-nonsense commitment to faithful accounts of a 'real' world (579, italics in original).

McCarty points out that the revolutionary force of the said "radical historical contingency" have led theorists such as Ingold to shift from "knowledge that" to "knowledge how" and to reconceive the world in terms of skills. But this raises the ontological problem of how to come up with Haraway's "faithful accounts of a 'real' world".

In answering these questions, I should first say that I am sympathetic to Donna Haraway's general epistemological points regarding situated knowledge, which is perhaps not surprising, given that we share inspirational sources in phenomenological philosophy. I definitely agree, on the one hand, that we have to accept the historical contingency of our beliefs, dependent as they are on the way we engage with the world to form them. And on the other hand, this should not lead us into relativism. I consider myself a pragmatist realist, not in the Peircean sense where reality is that on which science converges in claiming the existence of[2], but in a phenomenological sense: With Heidegger and Merleau-Ponty I would say that we are always already in the world which is as it is on the background of our agency in it. The split between subject and object, between cognition and world, is a secondary one, building fundamentally on "taking a step back" from the world we are always already engaged in and interacting with. Speaking ontologically—and with the under-

[2] Peirce (1958).

standing I get from the anthropologist literature that McCarty refers to in his contribution to this volume – it doesn't make sense (as Popper did and others have done after him)[3] to talk of a first world of nature and a second world of culture. The natural world we live in is a cultural one, formed by our cultural interactions with it, and vice versa. Therefore, I find it problematic to speak (as objectivist realists would) of the ontological existence of one world that we epistemologically speaking have different views upon: Our "views" of the world are not static observational views, but are interactional views; *i.e.* we form and are formed by the world in dynamic interaction and our "views" are part of this forming and being formed.

Potentially, we can say, as McCarty does, and as I think Haraway would, too, that different cultures have different "realities", because different cultures engage in (and in reaction, correspondingly are formed by) different interactions. They do so, however, around what Charles Taylor called "human constants" (Taylor 1985) as well as in interaction with natural laws etc. Hence it is not the case that "anything goes", and, though there may be more equally good answers to what the world is like, not any and every answer is equally good (*i.e.* no relativism on my part). For each culture, there are facts of the matter regarding the way the world is structured – and structurable – for them. Providing an explication of these facts of the matter is, I think, providing the "faithful accounts of a 'real' world", based on a world reconceived in terms of skills, which McCarty calls for with Haraway and Ingold.

As a final comment (also upon prompting from McCarty), let me revert again to the overall question of this special issue concerning the role of models in the Digital Humanities by explicating how computer models figure in my pragmatist realism and my understanding of knowledge as situated: As indicated above, on my view computer models may provide ways to simulate new interactions with the world. In this sense, they may indeed provide us with "new worlds" – or at least altered ones. Nonetheless, the novelty and strangeness of these altered worlds will be delimited in their outset by the framing of the modeler's imaginings. The possibility of computer modelling thus does not fundamentally change our ontological and epistemological situation, but it does hold the potential for a number of new specific experiences. Hence, it also holds the potential for us to develop specific forms of situated knowledge not possible in the physical world alone. This situated knowledge will, however, still be the knowledge of embodied beings living in a physical world. No matter how immersed we are in a digital "virtual world", we will still be immersed as physical beings, who *e.g.* sit on chairs, interact with keyboard and mouse, get sore shoulders from cramping up behind the screen, etc. Our apparent "virtual experiences" and "virtual situatedness" will therefore always be those of a real,

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3 *E.g.* Bereiter (Bereiter 1995). Popper argues for his position in (among others) Popper (1972).

embodied person. That is, they will in point of fact be real, embodied experiences, not of virtuality per se, but of interacting in hybrid physical-virtual contexts. And the situated knowledge developed through this interaction will reflect this.

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Multiple Models.
In the Mind and in the World

Barbara Tversky *

Abstract: *»Multiple Modelle. Im Geist und in der Welt.«*. Models, in whatever sense, have a dual status: they are what they are and they represent something else, even Borges' (1999) legendary point-to-point map. Representations select, add, and distort the information they represent. Models are meant for more than representation; they are meant as thinking tools, to promote inference, discovery, and creative thought. Research has shown that representations created on the page or in the air (gesture) have an accessible semantics and syntax and that such representations promote thought through a wordless conversation between the eye and the hand and the (sometimes virtual) page.

Keywords: Model, representation, inference, diagram, sketch, gesture.

1. Introduction

Model is one of those abundantly useful words that gets used abundantly by many communities in varying senses. Whether a model airplane or a model of good behavior or a business model or fashion model or a mathematical model or a mental model – what these seemingly disparate examples have in common is that they *represent* something else. Now, *representation* is one of those abundantly useful words that gets used abundantly in varying senses, so it's not clear we've made progress. But let's dig a little deeper, starting with the concept of *representation*. A common view of *representation* is that it extracts certain features and relations from whatever it's representing, but not all. It maps elements and relations in the represented world to elements and relations in the representing world. Whoever or whatever created the representation presumably selected those features and relations for a reason. A paradigmatic example of a representation is a map; it takes places and relations among them

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in the real world to places and relations in the representing world, the map. Someone designing a map for cyclists would select different features and relations than someone designing a map for drivers. Representations do more than select. They can also add information, say names of towns and streets, geographical borders, icons for restaurants and hotels, bands of color for depths of oceans or altitudes of mountains, and they can distort information, say straightening roads and enlarging them. Weather maps add notations for weather patterns that are invisible.

A model generally does more than represent. It is meant to go further, to encourage thought, to allow inferences, discovery and creative leaps. It's a thinking tool.

Models need not be tangible. Models can be mental, a set of beliefs of how something, a machine or a government or a person, operates. Of course physical phenomena, the firings of neurons, underlie mental models but mental models are not equivalent to the firings of neurons or even the specific firings of specific neurons. Models can be created by words, which have physicality in the form of sound waves or marks on a page, but again they are not equivalent to their physical instantiation. I can use words instead of a map or a diagram to tell you how to get from the train station to the hotel or how to operate the ticket machine for the train and you can use those words to create a mental model. If my words created from my mental model and your mental-modelling are precise enough you should be able to buy a ticket and arrive at the hotel. Even if, as is typical, much information is left out; representations and models are always used in a context of shared understanding.

Even if the words are carefully crafted, turning a mental representation in one mind into the right set of words and translating the words into a mental model in another mind can be effortful and error-prone, especially when the spatial array or the set of actions are complicated. Words are wonderful, I use them frequently and rather like them, but they bear arbitrary relations to meaning.

There are other forms of communication, both for self and for other, that have more direct correspondences to meaning. I'm thinking, of course, of gesture and graphics. By gesture I mean poses or actions of the body, especially of the hands and head, that act on thought rather than on the world. By graphics I refer to marks on a virtual page, with a broad scope for both. Marks could be the parts of a model of a building or a molecule and a page could be a screen or the face of a rock or a virtual 3-D space that stands for a building or a molecule. Graphics also include sketches, photos, maps, charts, diagrams, and such. There are two important points here. The ways that information is represented in gesture and graphics is more natural, immediate and direct than the ways information is represented in words. Next, both gesture and graphics are in the world, not in the mind. They are outside the mind and not only can be sensed but must be sensed by the body. Of course we can imagine gesturing and imagine seeing or creating graphics but imagination is between the ears, and the stuff that's beyond the ears and can be sensed has a different status and different effects. And of course words can be outside the mind and sensed by the body but they fail the tests of naturalness and directness of representation.

So far, a lot of words. Now for some action. Or truthfully, words that describe research activities that give backing to and expand the claims. Because we thought that representing and thinking with words is far from sufficient to understand how people represent and think about many of the important things in their lives, faces, bodies, objects, spaces, and events in time, we studied those one by one to uncover how they are represented and thought about (Tversky 2005a, 2005b; Tversky 2009; Tversky, Zacks and Hard 2008). The upshot: mostly not in words; each followed its own logic though descriptions of each in words turns out to be fascinating in and of itself. Then we turned to the spaces people create to expand their own thought. These have a long, long history. Cave paintings date back at least 35,000 years. Images of maps, animals, people, and mysterious symbols incised in stone are ancient and scattered across remote parts of the world. What roles these served for the people who made them or viewed them can only be a matter of speculation but the difficulty of making them and their ubiquity attest to strong human–and only human–desires to create and contemplate them.

2. Graphics

One line of research has been showing how graphics communicate (Tversky 2009): what are the semantics and pragmatics of graphic displays and how do people use them for comprehension, inference, discovery and creativity? Graphics make use of marks on a page and place on a page to convey a range of meanings quite directly. Gesture turn out to be similar, but of course also different. Let's start with graphics even though gesture comes first, phylogenetically and ontogentically. Again maps serve as a paradigmatic example: maps map; they use elements and spatial relations on a page to represent elements and spatial relations in the world. Visual-spatial representations of people, animals, objects, and mechanical systems do the same. Many other sets of concepts that are not inherently spatial can be spatialized: mandalas, the Periodic Table, organization charts, and graphs among them.

2.1 Place on a Page

Even preschool preliterate children can use place on page meaningfully. They can put stickers along a line on a page to represent the temporal relations of breakfast, lunch and dinner or the quantitative relations of handfuls, bag-fulls, and shelf-fulls of candy or their preferences for foods. They are inclined to put greater quantities and values up rather than down. Older children readily use proximity on the page to represent proximity on an abstract dimension, time, quantity, preference. Why up? Most likely because going up means countering gravity, so going up takes strength and health, because people grow taller as they grow older, that taller people and buildings and trees are stronger, that more money makes a taller pile, that healthy energetic people stand tall and weak depressed ones are stooped – the vertical dimension is loaded. All (or almost all) good thing go up; it's overdetermined. The horizontal dimension is more neutral though reading order confers substantial directional preferences and handedness confers value preferences.

2.2 Marks on a Page

There are several kinds. First there are words and word-like symbols and abbreviations. Next there are depictive elements, presumably the original foundations of ideographic languages, depictions that resemble what they represent like a depiction of the sun or a crescent moon as well as depictions or icons that represent figuratively, like the scales of justice or a trash can for deleting files or a file folder for creating them. The elements we have been most interested in are a third kind, meaningful abstract forms: dots, lines, arrows, circles, boxes, and blobs. It's a long story, so just a few examples here. In a series of experiments in which people interpreted and created graphics, we found that these forms have context-sensitive meanings that have shared readily grasped meanings. Dots can represent intersections in maps, people in social networks, ideas in knowledge networks. Lines connect dots. They serve as paths in maps and relationships in social networks and connections in knowledge networks. Boxes contain one set of things and separate those things from things in other sets. The Periodic Table elegantly puts each separate element in a box and arranges them in rows and columns that represent their molecular properties.

2.3 Using Graphics

We've not only looked at how graphics are designed to represent a range of information, we've also looked at the ways different forms of graphics serve learning, comprehension, inference, discovery and creativity. These interact interestingly with expertise, ability and task. Maps allow a plentitude of inferences based on proximity and direction as well as terrain. So does the Periodic Table. The same information presented in different ways encourages different inferences, for example people interpret bar graphs as discrete comparisons and lines as trends. For learning and comprehension, clarity is critical. Creating either a visual or verbal explanation of STEM phenomena increases learning but creating a visual explanation is far more powerful (Bobek and Tversky 2016). For design, art and data discovery, ambiguity is productive because it allows for reconfiguration and reinterpretation. Architects and artists say they have conversations with their sketches, they draw for one reason but when they examine what they've drawn, they make unintended discoveries. From those they get new ideas (Tversky and Suwa 2009). The same processes of discovery hold for scientists trying to understand a large and complex data set.

3. Gesture

Like graphics, gestures also map and spatialize. They use actions in space and place in space to map meanings directly. Gesture has some advantages over graphics, and some disadvantages as well. Gesture needs nothing more than the body we were born with, no pencil, no paper. Gestures are dynamic, so perhaps better suited to represent dynamic information, change over time. But gestures are fleeting while graphics on a page stay still in front of the eyes to be contemplated and revised. We have been studying the roles of gesturing and different kinds of gestures for both those who view gestures and those who perform them. Gestures commonly accompany speech and often add important information not conveyed by the words. The same explanation in words, say of arrangements of events in time or explanations of the workings of an engine, are understood differently depending on the gestures that accompany the speech. More surprising is the finding that the gestures people make alone in a room without speaking influence their own understanding and memory. In one study, students alone in a room studied descriptions of environments such as a small town or a large gym with four or eight landmarks and paths among them (Jamalian, Giardino and Tversky 2012). They knew they would be tested and that the tests would require inferences, such as spatial relations from perspectives different from those in the descriptions. A majority of participants gestured while reading at least one of the four descriptions. They produced line-like gestures for paths and point-like gestures for landmarks. That is, as a set, their gestures formed models of the environments. Those who gestured performed better on the tests than those who didn't and those who gestured for some descriptions but not all performed better on the descriptions for which they gestured. Another group was required to sit on their hands; they performed worse. They rarely looked at their hands so the facilitation seems to be spatial-motor. Gesturing clearly helped them think. We think the spatial-motor representations created by the gestures translated the words into thought.

4. In Sum

Models are necessary for thinking; by omitting, adding, and distorting the information they represent they can recraft the information into a multitude of forms that the mind can work with to understand extant ideas and create new ones. Models take elements and relations among them in the represented world and map them onto elements and relations in the representing world. In the cases of tangible, diagrammatic, and gestural models, the elements and relations are spatial. The fundamental elements are dots and lines, nodes and links. A dot can represent any concept from a place in a route to an idea in a web of concepts. Lines represent relations, any relation, between dots. As such, spatial models rely on more direct and accessible mappings than language, which bears only arbitrary relations to meaning. These mappings can be put into the world and made visible or visceral in graphics and gesture. Putting thought into the world promotes thought in self and other.

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Iconicity in Cognition and Communication

Christina Ljungberg *

Abstract: *»Ikonizität in Kognition und Kommunikation«*. Iconicity is fundamental to creative processes of reasoning such as modelling. We use models not only to orient ourselves in the physical world surrounding us but also as ways to sketch out problems by "mapping them," describe processes, or make decisions by using models such as diagrams, maps, or schemata. Mental images are icons, and icons can lead to new and rare insights and to the discovery of relations that would not be recognized without their iconic representation. Discussing the relationship between modelling, reasoning, and creativity, this contribution argues that iconicity is essential to reasoning, communication and mutual understanding, besides being inherently performative. The paper demonstrates its argument with examples from picture viewing, map reading, and mental diagrams in verbal language.

Keywords: Iconicity, diagrammatic reasoning, modelling, analogy, similarity, visuality, performativity.

1. Introduction

Thinking involves experimentation, trying out various possibilities. Besides other cognitive instruments such as words, images and other signs, a model is one of the heuristic devices that we deploy in such experimental contexts in order to probe and explore new fields of thoughts and ideas. Models are internal (mental) or external diagrammatic representations. This is why iconicity – the general characteristic of mental images – is essential to cognitive processing; it builds on perceptual similarities and contrasts. We depend on models, not only for orienting ourselves in our physical environment but also for the ways in which we sketch out problems by "mapping them," describe our experiences or make decisions by means of diagrams, maps, and schemata. Iconicity is fundamental to constructing models because mental images are icons, and interpreting icons can lead to the discovery of relations not otherwise recognized so that new and even surprising insights may be obtained.

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2. Iconicity

Iconicity is a semiotic concept introduced by Charles Sanders Peirce, the founder of modern semiotics. Peirce divides signs into three classes, iconic, indexical and symbolic, with respect to the way each sign relates to its (dynamic) object. Indices stand in a real or causal relation to the object they indicate; symbols are related to their object by habits or conventions, while icons are, roughly, associated with their objects by being, in some way or other, similar to them. This similarity can be a visual likeness in the sense that the sign resembles the form or colour of its object, but it may also be of an abstract kind, in the sense that it merely represents its structure, in which case the icon is a diagram. A diagram may have the form of external representation, on paper or as a three-dimensional model, or it may be a mental image of the object it represents. In the sense that interpreting and understanding a sentence, for example, or any other kind of information, means understanding how its constituent parts are related, *understanding* means creating a mental diagram (see Nöth 2015).

2.1 Iconicity and Analogy

Analogy, as Aristotle defines it, "is when the second term is to the first as the fourth to the third [and] we may then use the fourth for the second, or the second for the fourth" (*Poetics* 21). In the study of iconicity, analogy comes into play when we go one step further and subdivide the icon into its three Peircean subclasses of images, diagrams and metaphors. Whereas icons of the image type resemble their objects by some distinguishing features, and diagrams represent the mere structure of their object, a metaphorical icon is a sign that evinces a relation of similarity to some other sign, which is mediated by a third (the classical *tertium comparationis*). Metaphors are thus iconic mediators between ideas. As Mark Johnson (1981, 42) points out, "all theories are elaborations of basic metaphors or systems of metaphors". As far as metaphorical models are concerned, the focus is on diagrammatic iconicity. Both scientific and technological models as well as creative thought processes are essentially diagrams. Any analogy is a diagrammatic icon since it represents a parallelism between the structures of two conceptual domains – forming a structure that makes the relations between diverse objects, external or internal, more intelligible.

Take, for instance, a map. For a geographical map to fulfil its function, there must exist a "structural analogical relationship of the scaled topographic map to reality" (Woodward 2001, 56). A map represents points in space that are diagrammatically arranged by means of map signs. Even though map signs are culturally constructed, the structural similarity of a map to its territory is a concept that, as Woodward argues, is "fairly readily understood" (2001, 56). This is what enables the map maker as well as the map reader to visualize a region or a route, project its development or implementation, or to make thought experiments by modelling a plan of action. It is this diagrammatic modelling that links cartography so closely to the nature of human cognition and to our orientation in real space. Models such as maps are ideal instruments for orientation, since they possess the unique facility to permit us both to "enter" the map, position ourselves on it and within it as well as above it, allowing us to visualize our position inside it as well as the "full picture" from above. This is why the diagrammatic icon is our main interest in this paper. Diagrammatic iconicity is the prototypical characteristic of reasoning since reasoning is to arrange ideas diagrammatically.

3. The Relation between Modelling and Reasoning

"Diagrammatic reasoning", as Peirce (CP 2.272) calls it, is the only cognitive procedure by which we can obtain new knowledge. A diagram only shows the relations existing between its constituents; it does not interpret them. Interpreting is reasoning, and in the process of interpreting the relations presented by a diagram, its interpreters can make diverse inferences by which they may obtain insights that the diagram itself does not convey. This is why observing a diagram can create new knowledge.

3.1 The Creative Process of Picture Viewing

To illustrate this I would like to have a look at a picture such as Pietro Perugino's *Christ Delivering the Keys of the Kingdom to St. Peter* (ca. 1481-2, Figure 1), which is, strictly speaking, a diagram employing the main elements of the central perspective – horizon line, vanishing point and orthogonal lines. Since the actors in the foreground, being centrally and symmetrically placed, attract our immediate attention, this is where we start. What we see up front is an event, carried out by the two actors in the center, one standing and one kneeling, with a large key in profile connected to a second key held by the figure to the left, who is in the process of handing it over to the kneeling figure on the right. We can tell that these two actors are the most important ones because of their position in the painting and that the significance of the gesture of reverence is shown by the surrounding group of people. Because the audience are all so closely observing what is going on, this effectively draws our attention to the center, too. Further back, behind the front actors, we discern some smaller characters, who look as if they were standing on top of the front actors' heads. We also see an open square with lines that converge on the doorway of the temple in the background, making clear that this is the door for which the keys they carry will fit.

How do we process this picture? By using “diagrammatic reasoning”, we employ the picture as a diagram of perspective and mentally calculate the distances between the various objects that it represents, and thus we draw our conclusion on how the objects are related in their topographic and social space. First focusing on the two figures up front, the bright open space between them has us move our gaze towards the horizon line guided by the diagonal line behind the head of Christ, then connecting them with the temple door, which is diagrammatically positioned where the projections intersect at the picture’s vanishing point. Viewing the picture thus means that we, in a process of experiment and discovery, can gain new information from the picture sign by manipulating its parts according to certain rules – and in so doing, acquire information about how the objects making up the diagram are interrelated. From there, we infer what the scenario means.

Figure 1: Pietro Perugino, Christ Delivering the Keys of the Kingdom to Saint Peter (ca. 1481-82). Fresco. Rome (Vatican), Sistine Chapel

Public Domain: Wikimedia commons.

One could well object that the event the painting represents is a well-known Biblical narrative that legitimates the Christian Church and that diagrammatic reasoning is therefore unnecessary. Does the image not simply depict what the title states? It is true that the title is necessary to indicate the names of the two protagonists in the center, but otherwise a viewer familiar with the cultural background in general can come to an understanding of the painting’s meaning by using diagrammatic reasoning alone. Even ignoring the main event portrayed in the painting, the diagram it forms make viewers understand that the act depicted is of major importance. While keeping in mind that Perugino's use of the then newly invented Renaissance convention of perspective is unique to Western art and may therefore not have the same impact on a non-Western viewer, the suggested relationship between the gesture, the key and the temple door would incite as well as aid most viewers to solve the riddle of its meaning.

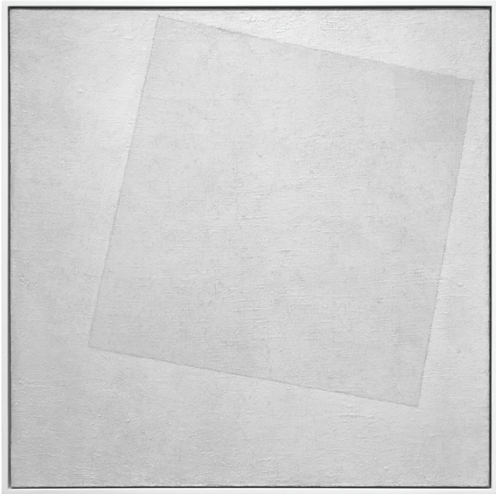
3.2 The Performativity of Diagrams

This example shows why the convention of the central perspective has been enormously successful in the history of painting. Centering everything on the eye of the beholder, it functions, in the words of John Berger, "like a beam from a lighthouse" since "[p]erspective makes the single eye the center of the visual world" (Berger 1968, 16). By this device, the painting becomes a diagram, instigating diagrammatic thinking, and since this process is less about the concrete shapes and forms of the figuration represented than about the dynamics, it opens up the potential relationships it depicts. This points to the performativity of diagrams: by inciting diagrammatic reasoning, which is less about structure than about manipulation and experimentation, thus trying out prospective alternatives, it produces new information and insight and, in so doing, creates new knowledge.[1]

Diagrammatic reasoning also functions when we try to understand paintings with less explicit diagrammatic structure and symbolic content than in Perugino's painting. Even contemplating a picture such as Malevich's *Suprematist Composition: White on White* (1918, Figure 2), one of the best-known examples of twentieth century avant-garde Russian art, helps us consider various alternatives and come to an interpretation. Malevich's picture has often been given a mythologizing reading involving a quasi-mystical experience (Faerna 1996). While its negation of figuration and pictorial composition has been interpreted as a "leap into a mystical beyond, inner as well as outer" (West 2017, 92), which enables the viewer "to penetrate the universe through our imagination" (Hultén 1965), diagrammatic reasoning reveals intriguing material and phenomenological conditions seldom taken into account.

1 For an interesting analysis of Perugino's painting from a different perspective, see Michael Marrinan's essay 'On the Thing-ness of Diagrams' (2016, 28-9).

Figure 2: Suprematist Composition: White on White. Kasimir Malevich (1918).



Public Domain: Wikimedia commons.

Despite its title, the painting is not monochromatic, especially if we compare it to Yves Klein's *IKB 79* (1959).[2] In contrast to Klein's blue, one of nearly two hundred monochromatic blues, in Malevich's painting white is not just white but a bluish square with imprecise outlines placed asymmetrically on a beige background. This does not only put colour designation into question but since figure and background are only distinguished by a minimal difference, the viewer gets the impression of seeing the figure placed on top of the background. However, as Frederik Stjernfelt (2007, 288) has pointed out, the square could even function as an ambiguous pattern, a *Kippfigur* shifting between object and background so that the object changes from being an object in the foreground and instead becomes a hole in the background, opening towards something else – or a void? Even though the difference between the two surfaces is minimal, one could also imagine that the square could refer to a zone of gravitation, which makes the square's oblique position one of instability, threatening to disappear into the background. It is precisely this diagrammatic relationship between figure and ground that gives the painting its compositional

2 The comparison between Malevich's *White on White* (1918) and Klein's monochromatic blue *IKB 79* (1959) also clearly demonstrates the difference between a diagram and an icon of the image type. Whereas Malevich wanted his art to express "the supremacy of pure feeling or perception" (MOMA 1999, 85), which would seem to correspond to an image icon, it is Klein's holistic aesthetic which actually achieves this. As Klein writes, "Art does not depend on vision but on the sensibility that affects us, on affectivity therefore, and on that much more than all that touches our five senses" (Klein 1958, quoted in Stich 1994, 85).

tension and invites experimenting and acquiring or drawing further conclusions through diagrammatic reasoning.

4. Modelling and Creativity

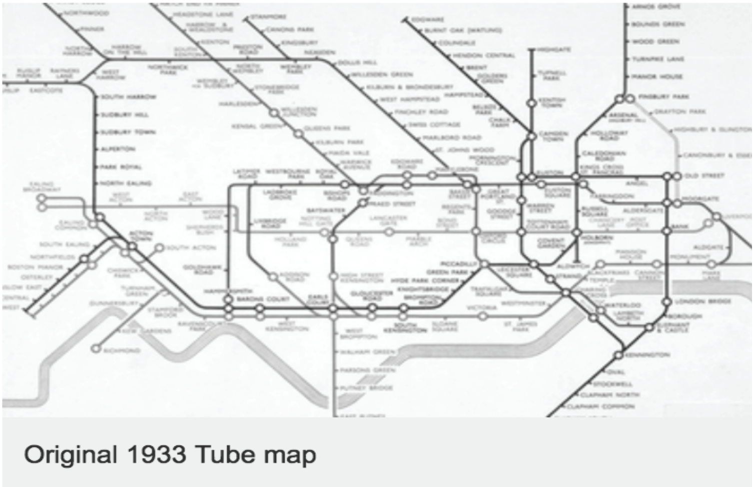
Material models are mental diagrams before they become external signs. They also live on as mental diagrams in the minds of those who interpret them. Material models such as maps are telling instances of how we operate on models to try out various possibilities, make decisions and, in so doing, find new solutions and create new knowledge.

4.1 Creative Solutions

Figuring out one's travel route on the London Underground Tube map (Figure 3) is an instructive example of how we operate creatively on a diagram. The map only shows the relationships between the various stations, without specifying the best connections between the point of departure A and a goal B. By experimenting on the various possibilities of finding the most advantageous route from A to B, including line changes, we are capable of modelling an itinerary that suits our purpose. The map *per se* does not mark the specific route we are taking. It is only by mentally manipulating the alternative routes offered by the map that we can obtain this information, that is, that we as users are able to trace new alternatives of new routes from the map. We may choose to change at different stations, or use a different combination of lines to avoid changing more than once – although the diagram does not directly indicate how to find the quickest and most efficient route.

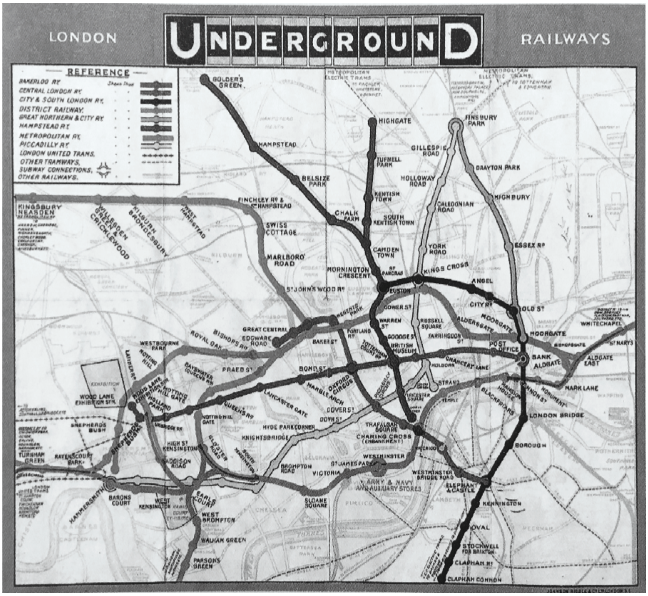
A comparison between Harry Beck's famous map of 1933 and the first London Underground map of 1908 (Figure 4) shows how innovative Beck's map was. The London Metropolitan Railway – which was the world's first underground train line – had opened in January 1863 but, operated by several railway companies, developed so rapidly that it left passengers completely confused about how to find the easiest way to go from A to B. In 1908, finally, railway company operators united and pooled their resources to create a joint advertisement in the form of a free publicity map (Figure 4).

Figure 3: Harry Beck's original London Underground Map (1933), Transport for London



Source: <https://tfl.gov.uk/maps/>.

Figure 4: The First London Underground Map (1908)



Source: By Unknown, <http://homepage.ntlworld.com/clive.billson/tubemaps/1908.html>, Public Domain, <https://commons.wikimedia.org>.

However, the amount of information collected on the 1908 map proved too complex for many travelers. Displaying the lines of the eight various railway companies, labeled and colour-coded, the relative positions of their stations along the lines, the station's connective relations with each other and the various fare zones, the map of the sprawling Tube network was quite a challenge for Londoners and even more so for visitors unfamiliar with both the locations and the system. In addition, the additional information of important destinations such as hospitals, main theatres, hotels and cemeteries included on the map cluttered it and made it difficult for its users to read and orient themselves efficiently.

What makes Beck's map so revolutionary is thus the diagrammatic reduction of a complex set of information into an operational network.[3] By abandoning geographical detail entirely and simplifying the complex structure by geometrically straightening the lines to have the stations appear vertically, horizontally, or at 45 degree diagonals, Beck managed to represent the London Underground as a circuit diagram. First rejected by the publicity department on grounds that his design was too radical, the map was however granted a trial print run, which met with overwhelming success – this was exactly what the public wanted. That it became a template for transport systems worldwide and still is in operation after almost 85 years testifies to its merit.

4.2 Architectural Models

Similarly, in architecture, the strength of an architectural model or blueprint of a building is that while it represents the overall framework of a construction, its various interrelated parts can be changed, moved or discarded, allowing for an entirely new structure to be created that may not have been intended from the start. It abstracts from the concrete kinds of material in which it will be constructed, which is one of the key features of diagrams since this allows "the mind more easily to think of the important features" (Peirce 1998, 13). Nevertheless, as useful and productive as this kind of modelling are to those who are used to thinking visually, architectural drawings, like maps, need some practice to be mentally visualized and to convert the orthogonal plan into a mental diagram of a finished building. That is why architectural renderings, virtual two-dimensional images or animations showing the attributes of a proposed project, have become an indispensable tool for explaining to customers and politicians what the finished construction will look like.

[3] As Kenneth Fields and William Cartwright (2014, 349) point out, Beck was most likely influenced by many maps, but he "pushed the boundaries and created something different, innovative and experimental", which, I would argue, proves the strength of Beck's diagrammatic reasoning and subsequent reduction.

4.3 Mental Diagrams and Verbal Language

Mental diagrams are also at work in verbal language. We think in words, images and other signs arranged in mental diagrams – mental models – so that our thoughts can arrange and rearrange the diagram in mental experiments while probing and exploring new possibilities. Although words are symbols, they also evince iconic and indexical properties – otherwise they would be too abstract to represent anything. Iconicity, especially diagrammatic iconicity, plays a crucial part here. Syntactic deep structures are diagrams of what the sentences mean, and there is also iconicity in the sequential order of the words of our utterances. In the classical example, Caesar's *veni, vidi, vici*, the shortness of the words is an icon of the short time in which Caesar conquered his opponents. Furthermore, as Winfried Nöth (2015, 23) points out, the order of the words is a diagram of the order of the events during that battle. Diagrammatic iconicity can be found at all levels of language use: at the level of sentences, phrases and words. Verbs, for example, involve mental diagrams of the agents involved in the action they represent.

Mental diagrams are systems and structures, and to the degree that language is a system that imposes structures on utterances and texts, verbal thought thus has diagrammatic form. Furthermore, a word is also a mental diagram of its phonological form, a mental schema of the order, the articulation and the stress pattern of how its vowels and consonants are to be uttered or written. That is why analogies are important to linguistic theorizing and modelling. Diagrams are important factors of language change, language evolution, and language acquisition, as the studies by Douglas Hofstadter (1995), Terrence Deacon (1997), Esa Itkonen (2005), Dieter Wanner (2006), Olga Fischer (2007), Winfried Nöth (2008) and others have shown, all of whom have given evidence that the basic mechanism of learning is analogy.

5. Conclusion: Iconicity as a Precondition for Communication and Understanding

Iconicity is then fundamental to communication and mutual understanding, in oral conversation as well as in writing and reading. It also plays an essential role in creative thought. It is the mental images, diagrams and metaphors triggered by icons that enable us to understand an utterance or create textual worlds from the little black marks on the page. While texts consist of symbols, that is, letters and words, these symbols create mental images of relations, fictional worlds in which we can move and which we can see in our mind, by applying our own experiences and cognitive makeup to the text. This, in turn, shapes our individual fictional architecture, its furniture and its cartographic imagination in the reading process – and accounts for the creativity it involves.

Iconicity thus plays a paramount part in cognition and communication. Observing a picture, orienting oneself in a text or finding one's way on a map are all complex creative cognitive activities involving modelling through diagrammatic reasoning, making use of analogy, similarity, and visuality in this process.

6. Discussion

Barbara Tversky had two questions to my position statement:

1) Peirce's diagrammatic reasoning – is all reasoning actually diagrammatic and the only way in which we can get new insights? Does diagrammatic reasoning really apply to Perugino's painting, which is so heavily loaded with religious symbols?
2) David Woodward quote: Barbara did not agree with Woodward's statement that there must exist a "structural analogical relationship of a map to reality" – as an example, she suggested a cognitive map, which does not need this "structural analogical relationship".

To which I answered

1) Diagrammatic reasoning, in the sense of C.S. Peirce (CP 2.272), is the only cognitive procedure that provides us with new knowledge. This is because a diagram only shows the relations existing between its constituents but it *does not interpret them*. Interpreting is reasoning. In the process of interpreting the relations presented by a diagram, the interpreter can make diverse inferences by which the interpreter obtains insights that are not conveyed by the diagram itself. That is why reading a diagram *can* result in new insights that the diagram itself does not formulate. As I argued, even though the title of Perugino's work clearly states the name of the two protagonists, a viewer unfamiliar with the cultural background could arrive at an understanding of the painting's meaning by diagrammatic reasoning only, without knowing the Bible narrative. The relationship proposed between the gesture, the key and the temple door provides clues for solving the meaning of the picture.
2) My point does not concern "cognitive maps" in the usual sense but geographical maps – a geographical map does not fulfill its function if it does not have a "structural analogical relationship" to reality, which is what it is made for, otherwise people could not use it for orientation. At the same time, all maps could be said to be cognitive as well as being "protocols of cognition" – they inform us about their own processes of creating meaning by their selection of and the relation in which they represent the objects in question.

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Modelling in the Humanities: Linking Patterns to Principles

Rens Bod [*]

Abstract: *»Modellieren in den Geisteswissenschaften: Verbindung von Prinzipien und Mustern«*. Modelling is ubiquitous in the humanities: while scholars do many things, the search for patterns and principles, and the links between them, is found in all humanistic disciplines and periods. Modelling in antiquity consisted mainly of explaining and constraining patterns by means of principles. In the early modern period, modelling also included the prediction and refutation of patterns by means of these principles. Since the late nineteenth century, the focus shifted to interpreting and criticizing patterns by means of principles. I will discuss some commonalities between modelling in the humanities and in the sciences. The exploration of different modelling strategies and practices in the (history of the) humanities has just begun and may lead to a new field coined History and Philosophy of the Humanities (HPH), analogous to History and Philosophy of Science (HPS).

Keywords: Patterns, principles, modelling, exceptions, explaining, understanding, interpretation.

1. Understanding the World by Means of Patterns and Principles

The idea that the world can be understood in terms of empirical *patterns* and underlying *principles* is arguably one of humankind's most important insights. A pattern is a regularity observed across events or artefacts, with or without exceptions.[1] A principle is a generalization that brings together different patterns under a single denominator and which is usually said to explain the regularities. While patterns are empirical, principles are theoretical. Although patterns and principles had different meanings in different periods, the concepts seem to be universal. From China to Europe and from Africa to the Americas,

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1 On the concept of pattern, see McAllister 2011.

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people have searched for regularities and underlying principles in both the natural and cultural world.[2]

The quest for patterns and principles is not limited to the (natural) sciences, but is found in all knowledge-making disciplines, including the humanities.[3] Besides discovering patterns and underlying principles in planetary movements, diseases and in the evolution of species, scholars have also found patterns and principles in the transmission of texts, the evolution of languages and the development of artistic, musical and literary styles – to name a few. Coming up with theoretical principles that generalize and explain empirical patterns is one thing, but showing that there is indeed an explicit relation between the patterns found and the principles proposed is quite another. In fact, the problem of understanding the relation between patterns and principles has hardly been touched upon in the philosophy of the humanities while it has received considerable attention in the philosophy of science.

I shall argue that the humanistic practice of connecting patterns to principles can best be understood as a form of "modelling". However, the terms "model" and "modelling" are highly ambiguous in the literature. There appears to be no common terminology used by either scientists or philosophers.[4] This is not in itself problematic as it gives us some freedom to redefine "modelling" in a humanistic context. We will see that our notion of modelling has some commonalities with notions of modelling used in the natural and social sciences.

To explore what may be needed for an understanding of modelling in the humanities, I shall start with a bird's eye overview of this modelling practice in the history of the humanities. My overview, which focuses on the European tradition, suggests that questions such as "How does a philologist reconstruct a text from extant copies?", "How does an historian interpret an historical event or process?", "How does a musicologist analyze a piece of music?" and "How does an art historian interpret a painting?" are prime examples of modelling in the humanities. Yet they have rarely been analyzed from an epistemological perspective. This is partly due to the fact that humanities scholars tend to leave their modelling decisions implicit – and sometimes even deny that they are "modelling". One of my long-term goals is to make the implicit decisions in humanistic practice explicit. I thus take from the field of historical epistemology the notion that knowledge can only be adequately understood if studied in its historical development.[5] I maintain that modelling is not limited to the digital humanities, let alone to the sciences, but that concepts from the digital hu-

2 See Bod 2013a.

3 I will not go into the question of how the humanities could best be defined. For this, see: Bod et al. 2016; Bod and Kursell 2015. For the scope of the current paper, it suffices to refer to Wilhelm Dilthey's concept of the humanities ("Geisteswissenschaften") as the disciplines that study the expressions of the human mind – see Dilthey 1883: 29-30.

4 For an overview, see Koperski n.d. 25 September 2017, <http://www.iep.utm.edu/models/>.

5 For an introduction to Historical Epistemology, see Nasim 2013.

manities – where the notion of pattern has been used from its inception[6] – may help us in studying other humanities disciplines. In doing so, I will paraphrase questions like those given above in terms of patterns and principles. Thus the question “How does a philologist reconstruct a text from extant copies?” may be rephrased as: “What kind(s) of patterns does a philologist extract from extant copies and on the basis of what principle(s) does s/he use these patterns to reconstruct the original text?”.

We must keep in mind that humanistic practice is not limited to modelling. Humanities scholars do many things: they keep alive the works from the past through teaching and writing, they build and maintain archives, they aim at developing critical consciousness and historical responsibility, and they also pose research questions regarding humanistic artefacts. It is in these research questions that the notions of patterns and principles, and the relation between these two, are fully fleshed out.

2. Modelling in the Ancient Humanities: Explaining and Constraining

One of the oldest modelling practices in the humanities is found in philology. With the establishment of the Library of Alexandria hundreds of thousands of manuscripts – and remnants thereof – were brought together. Among the many copies of the same text, no two were alike. In some cases the differences were modest and had come about because of copying errors, but the discrepancies could also be substantial, consisting of whole sentences that appeared to be deliberate changes, additions or omissions. There were also texts that had only survived in the form of incomplete fragments. How could the original text – the archetype – be deduced from all this material? This was the guiding question for a long succession of librarians at the Library of Alexandria. Aristophanes of Byzantium (*c.*257-180 BCE) opted for an explicit philological method to figure out how an unknown word form in a manuscript can be identified as either an archaic word or as an error. He approached this problem on the basis of a concept of *analogy* (Callanan 1987). If one could establish that an unknown word was conjugated or declined following the same pattern as a known word, it could be taken as an archaic word; otherwise it was a corrupted word. Aristophanes defined five such patterns or rules that word forms had to comply with in order to be described as “analogous” (*analogía*). The word forms had to correspond in regard to *gender*, *case*, *ending*, *number of syllables* and *stress* (or sound). Aristophanes’s successor, Aristarchus of Samothrace (*c.*216-*c.*144 BCE), added a sixth rule: when comparing two word forms, both had to be

[6] See e.g. Ramsay 2005; Bod 2013b.

compound (complex) or *non-compound* (simplex) (Schironi 2004). The Alexandrian philologists thus used the designation of *analogía* as the underlying principle that generalized over the various rules of comparison. New rules for reconstructing manuscripts could be (and in fact were) introduced, but they had to follow the principle of analogy. This principle served not only as a generalization of existing patterns and rules but also as a constraint for new rules. While there were competing schools as well, in particular the school of Pergamon that focused on exceptions (*anomalía*) rather than rules, the Alexandrian method has withstood the test of time as a critical approach to text reconstruction. We owe a debt of gratitude to the insights of the Alexandrians, as well as to succeeding generations of tragedians and historians who employed their method, for the editions of Homer, Hesiod, Pindarus, Archilochus and Anacreon which have been handed down to us.

Modelling practices are also found in other ancient humanistic disciplines. In their descriptions of the Persian and Peloponnesian Wars, the historians Herodotus (*c*.484-425 BCE) and Thucydides (*c*.460-*c*.395 BCE) believed they could recognize a pattern in past events, namely that of rise, peak and decline. Herodotus found this pattern in both people and states, such as the tyrant Pisistratus and Athens, King Croesus and Lydia, and Darius and Persia: their fortunes rose and fell. Herodotus considered the pattern to be the basic structure of history: "For many states that were once great have now become small, and in my lifetime those that are great used to be small." (Herodotus, *Histories*, 1.5.) Thucydides also contended that the rise and fall of Athens and its disintegration during the Peloponnesian Wars had parallels with other historical periods. He believed that this pattern was analogous to human nature and could therefore serve as an "aid for interpreting the future" (Thucydides, *History of the Peloponnesian War*, 1.22.).

The Greek historian Polybius (*c*.200-*c*.118 BCE) found a different historical pattern, namely in the history of Rome. Polybius expressed great admiration for the way Rome succeeded where the Greeks had failed. Rome, he argued, refuted the pattern that had occurred in the history of Athens, i.e. a cycle of monarchy, aristocracy, oligarchy, democracy and, via tyranny, back to monarchy again (Polybius, *Histories*, 1.1-2.). Unlike Athens and other cities, Rome was immune to this cycle – and therefore to decline – because of its *mixed* constitution. Rome's governmental structure at the time of Polybius included a monarchy (the consuls), an aristocracy (the senate) and a democracy (the people's assemblies). According to Polybius this simultaneity broke the cyclical pattern, which turned the history of Rome into a non-cyclical history, or so he believed (ibid., 1.4.).

Although we know nowadays that Rome was also subject to decline, Polybius did try to find an explanatory principle for the two patterns he observed: the rise, peak and decline of the Greek city states, and Rome's continuous flourishing without decline. His principle of mixed vs non-mixed constitutions leads in the first case to prosperity and in the second to decline. Of course, Polybius' principle could only generalize over two patterns (one of which turned out to be incorrect), but he did search for a principle which explained the patterns he found. This principle could even make predictions for other city states, although Polybius never applied his principle to other situations.

The search for theoretical principles underlying observed patterns is also found in the study of literature, art and music. For example, Aristotle found regularities in classical tragedies that he explained by a set of poetical principles for "good" narratives (Aristotle, *Poetica*, XXIV, 60a16). These general principles were meant as descriptive generalizations underlying the patterns found in plays, poems and stories, but Aristotle's principles were soon used prescriptively by Horace and others as a normative guideline for constructing new poems. In the field of art history, Pliny found a pattern in Greek and Roman art, which could be defined by mathematical proportions known as the *canon* (Pliny, *Naturalis historia*, 34. 55.) Although Pliny did not find principles for what he called "beautiful" art, he did find mathematical principles for "good" art. In musicology, Aristoxenus found melodic regularities in Greek musical pieces, which he tried to explain by a few underlying principles that constrained the space of possible melodies without explicitly producing melodies (Gibson 2005, 169). These poetic, artistic and musical principles constrained the set of possible patterns without producing new pieces of theatre, art or music.

The relation between patterns and principles in Antiquity can thus best be described in terms of *constraints.* Patterns in the humanities cannot be formally reduced to principles, like in Euclidian mathematics. Instead, principles in the ancient humanities define the conditions or constraints within which these patterns and rules can play out. These principles are mainly used to explain patterns, and sometimes to predict and interpret patterns. This gives us a first clue as to the relation between principles and patterns.

3. From the Medieval to the Early Modern Era: Predicting and Refuting

After the fall of the West-Roman empire, European learning was concentrated in monasteries, cathedral schools and (later) universities. The basic university curriculum was formed by the artes liberales, which were subdivided into the so-called trivium, consisting of grammar, logic and rhetoric, and the quadrivium, which consisted of geometry, arithmetic, astronomy and music. While the practice of modelling continued, it was made subservient to biblical-theological authority. History writing in the West was dominated by Universal Histories that consisted of a narrative pattern that divided the time between the Creation and the Last Judgment into different periods (Mortley 1996). The underlying principle was the notion of biblical coherence: all narrative patterns had to be in accordance with biblical narrative. In poetics the main goal was to bring textual interpretation in accordance with Biblical interpretation (Preminger, Hardison, and Kerrane 1974). In philology, the Alexandrian method was briefly revived by Lupus de Ferrière (c.805-62), but philological practice in the West remained subservient to ecclesiastical authority (Gariepy 1967). Roger Bacon maintained that the old Latin manuscripts of the church fathers were the first authority in any attempted reconstruction of biblical texts (Roger Bacon, *Opus maius*, part III.).

With the advent of humanism, we see a renewed interest in empirical pattern searching and modelling. In philology, Angelo Poliziano (1454-1494) goes beyond the Alexandrian philological approach when he takes into account the genealogical relationship between extant copies (Poliziano 1970-1971). Poliziano realized that a group of completely consistent sources could still pose a problem. Assume that a number of sources – A, B, C and D – all agree on one point, and that B, C and D are entirely dependent on A for their information.[7] Should B, C and D nevertheless be included as extra evidence of the authenticity of A? According to Poliziano they should not: if derived sources were mutually consistent, they should be identified and eliminated (Poliziano 1970-1971, I.39.). Sources should be ranked genealogically so that their dependence in regard to an older source becomes clear. One anomalous manuscript can refute dozens of consistent manuscripts purely on the basis of its position in the genealogical ranking. This underlying principle is known as the eliminatio-principle (from eliminatio codicum descriptorum) or the "oldest source principle" (Maas 1960, 2).

Poliziano used his method with exemplary precision. His quest for genealogies of manuscripts resulted in highly accurate reconstructions of Terence, Virgil, Seneca, Propertius and Flaccus. But it is mainly after Poliziano that his philological principle revealed some of the most surprising patterns found in the early modern period, especially in the work of the philologist and historian Joseph Justus Scaliger (1540-1609). Scaliger aimed at unifying all ancient histories (Graeco-Roman, Babylonian, Egyptian, Persian and Jewish) so as to create the definitive historical chronology (Grafton 1983-1993). Scaliger therefore reconstructed various historical texts, among them Manetho's list of Egyptian dynasties. Using the information from these sources, particularly about the duration of the different dynasties, Scaliger was able to date the beginning of the first Egyptian dynasty to 5285 BCE. To his dismay this date was nearly 1300 years before the generally accepted day of Creation, which according to biblical chronology had to be around 4000 BCE. In order to "save the phenomena", Scaliger introduced a new time pattern – the tempus prolepticon – a time

7 This example comes (with slight modification) from Grafton 1991, 56.

before time (Scaliger 1658 [1606]). He placed every event that occurred before the Creation, such as the early Egyptian kings, in this proleptic time. Scaliger's solution may come across as artificial, but for a Protestant in around 1600 it was inconceivable to cast doubt on the Bible. Yet at the same time Scaliger was too consistent to give up on his philological method. It was only a couple of generations later when scholars and philosophers like Isaac Vossius and Spinoza realized that the only possible interpretation of Scaliger's result was that the earliest Egyptian kings had actually lived before the biblical date of the Creation. This meant that the Bible could not be taken seriously as a historical source. Scaliger's pattern of world history conflicted with biblical chronology, and this triggered a chain of biblical criticism that finally resulted in the Enlightenment.[8]

Thus, in the early modern era, a temporal pattern was no longer neutral but could be used to refute a formerly well-established world view. This is not to say that patterns were neutral in Antiquity – Herodotus and Thucydides also interpreted their findings, but their pattern (of rise, peak and fall) corroborated their world view rather than challenged it. In the early modern period, however, the discovery of certain patterns became critical as they were in opposition to the then accepted world view which they effectively refuted. This was not only the case for Scaliger's discovery, but also for discoveries in other humanities disciplines. In linguistics, Johannes de Laet designed a number of principles for comparing words in different languages, showing that there could be no relationship whatsoever between American-Indian languages and Hebrew. This effectively refuted the idea that Hebrew was the cradle of all languages (de Laet 1643). In music theory no hard distinction – with whatever underlying harmonic principles – could be found to distinguish consonant from dissonant intervals. This rebutted the centuries-old Pythagorean cosmic harmony.[9]

4. The Modern Period: Interpretation and Criticism

The first conceptual distinction between the notions of "humanities" and "science" was put forward in Giambattista Vico's *Scienza Nuova* (1725), but his work was ignored for almost a hundred years. It was in the nineteenth century when Wilhelm Dilthey (1833-1911) gave a foundation for the disciplines that we nowadays call humanities. According to Dilthey the humanities (*Geisteswissenschaften*) are concerned primarily with *verstehen* (understanding), whereas science (*Naturwissenschaften*) is about *erklären* (explaining) (Dilthey 1883, 29-30). Humanities scholars would be failing if they observed,

[8] At various places it has been argued that there is a direct line running from Scaliger via Saumaise and Isaac Vossius to Spinoza. See e.g. Israel 2002; Jorink 2010.

[9] See Cohen 2010.

counted, measured or hunted for apparent regularities. What they should be doing is searching for the motives and intentions of historical figures. Laying bare these inner mainsprings is more important than studying the external manifestations of the human mind. In this context one also uses the distinction introduced by Wilhelm Windelband (1848-1915) between an "idiographic" approach to knowledge (which is the study of the unique and the special) and a "nomothetic" way of studying (which seeks to generalize) (Windelband 1904). While the humanities were supposed to search for the unique, the sciences would deal with the general. This vision turned out to be extremely influential as it gave the humanities a powerful identity enabling them to differentiate and emancipate themselves from the other disciplines.

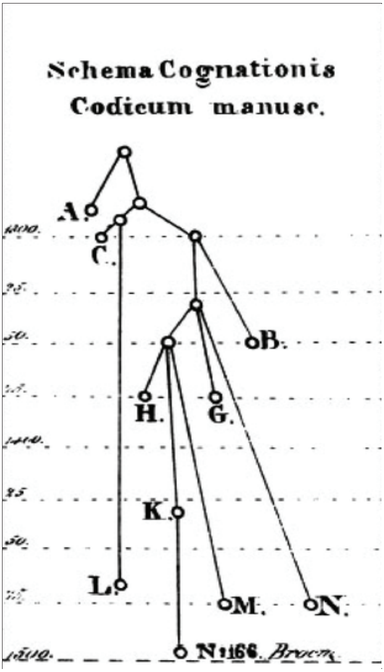
This constitutive separation between the humanities and sciences, however, did not correspond to actual practice in the humanities before the nineteenth century, as we have already seen. The search for patterns and principles and the search for a connection between them (modelling), both before and after the nineteenth century, simply continued in all humanities disciplines. When Dilthey's and Windelband's visions were gaining ground – from the early twentieth century onwards – modelling practices in the humanities continued. Such practices are found not only in linguistics (e.g. De Saussure, Jakobson) but also in philology (Lachmann, Greg), musicology (Schenker, Lerdahl), literary theory (Propp, Todorov), art history (Wölfflin, Panofsky) and historiography (the *Annales* school), just to name a few.

For example, in philology Karl Lachmann (1793-1851) created a principle-based method of text reconstruction that is known as *stemmatology*.[10] In this method, an external representation ("model") of surviving texts is built – a history tree or *stemma* – that can be used to reconstruct the original text from the patterns found in surviving texts. Many elements of stemmatology had already been in use for centuries, such as the concept of an archetype (the Alexandrians), the genealogical method (Poliziano), as well as the notion of a history tree which was used by Carl Johan Schlyter in 1827 (see Figure 1). However, Lachmann unified these separate elements into a systematic whole.[11] He believed that a history tree or stemma could be constructed on the basis of one underlying philological principle: *if an error is created in a version of a text then all descendants of that text contain the same common error*. On the basis of differences between extant texts, a stemma could be constructed. Lachmann distinguished three phases: *Recensio* (determining the genealogical relationship between the surviving texts in the form of a history tree), *Examinatio* (deciding on the primitive text) and *Emendatio* (emending so as to reconstruct the archetype). Thus modelling in stemmatology was not just a matter of

[10] For the fundamentals of Lachmann's theory, see Lachmann (1876) 2007. See also Ziegler 2000.
[11] Timpanaro 1963, 5-13. For an English translation, see Timpanaro 2005.

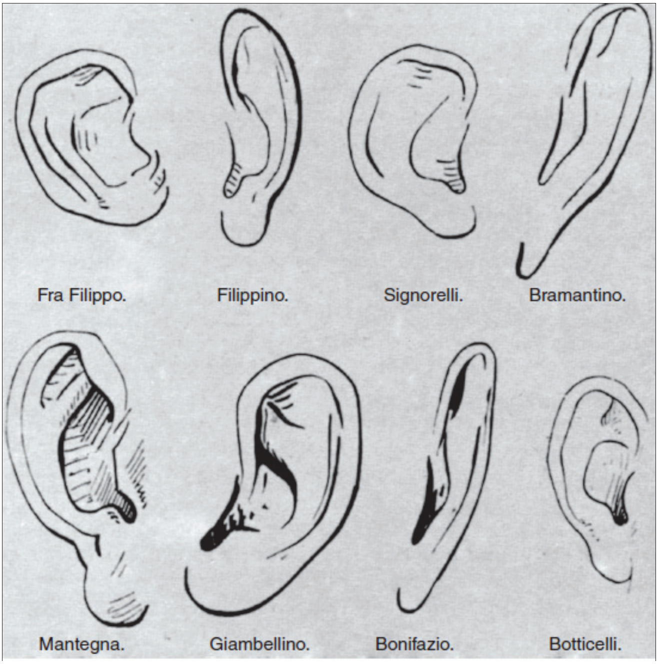
linking patterns in manuscripts to the underlying philological principle, but also of creating an intermediary representation, a stemma, which facilitated the modelling process.

Figure 1: The Earliest Known Representation of a Stemma by Carl Johan Schlyter (1827)



In art history, the analysis of stylistic patterns was initiated by Giovanni Morelli (1816-1891), who created detailed taxonomies of pictorial representations of ears, noses, hands and other parts of the body, as well as clouds, leaves, folds and individual brushstrokes in Italian art (Morelli 1890-1893). His underlying principle was that an artist’s personal style is found in the details of a painting over which the artist has no control. Connoisseurs and art historians were trained in the Morellian method and learned how to compare stylistic patterns across a wide corpus of paintings (see Figure 2).

Figure 2: Giovanni Morelli's Study of the Depiction of Ears by Eight Different Renaissance Artists (Morelli 1980-1993)



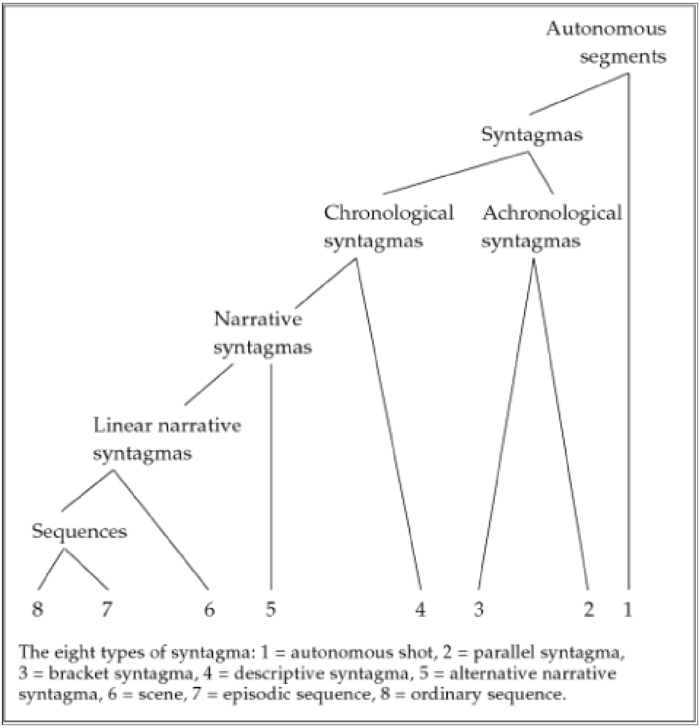
Morelli's method was also used in archaeology to classify Greek vases and reliefs. But his stylistic analysis was entirely based on details. It is thanks to the work of Heinrich Wölfflin (1864-1945) that we have stylistic principles with which not only all the separate parts of a work of art can be examined, but also their relationship to the whole. In his *Kunstgeschichtliche Grundbegriffe* (1915), Wölfflin introduced a gamut of new stylistic concepts that he grouped in five pairs of opposites in order to characterize style transitions (in particular from Renaissance to baroque). He defined notions like linear versus painterly representations, flat versus deep composition, closed versus open forms and clear versus diffuse representations, among others. His notions still form the basis of historical art analysis today. Yet Wölfflin's principles were also criticized by people like Walter Benjamin who in his essay *Strenge Kunstwissenschaft* (1933), who argued that Wölfflin neglected the social and cultural interpretations of paintings. Later work by Aby Warburg and Erwin Panofsky did take such interpretations into account.

The quest for relating patterns to principles is also found in literary studies. While it may not be surprising to find pattern and principle-seeking practices in the work of early formalist and structuralist literary scholars like Propp, Jakobson and Todorov, it is less well-known that those who reacted to and criticized structuralism – the post-structuralists – were also relying on patterns (as well as principles). This becomes particularly clear if we look at the work of Roland Barthes (1915-1980), who built on but also went beyond the long tradition set out by the formalists and structuralists. In his book *S/Z* (1970), Barthes started his famous analysis of Balzac's story *Sarrasine* by organizing the novella into a complex pattern consisting of 561 reading units ("lexies"). He then analyzed these units in terms of different meaning attributions, showing that Balzac's realistic text is full of symbolic and other connotations which can be interpreted in various different ways by the reader.

With these examples I do not want to say that modelling was uncontroversial in twentieth-century humanities. In historiography, for example, the opposition was strongly felt. While social-economic historians and (pre-war) cultural historians like Spengler and Toynbee searched for general patterns and underlying principles in history, their results were criticized by narratologists (who argued that only the "narrative" could give an account of an absent past), the critical school (which claimed that only general criticism could demythologize the past) and by postmodernists (who went farthest by arguing that any claim to historical truth is subject to deconstruction). Yet a closer look reveals that the pattern-rejecting historians criticized not so much patterns *per se* but "universal" patterns that were claimed to be culture independent. Their criticism made way for a quest for different patterns that were culture specific or ideological. In fact, some historians have found patterns in a historical epoch by employing categories and principles from that period. If a historian knows the rules of fifteenth-century art theory or rhetoric, for example, they can use them to analyze and interpret works of art, texts and other, even less obvious objects, dating from that time (Baxandall 1971).

In musicology and linguistics, as well as in the more recent disciplines of theatre studies, film studies, television studies and media studies, we find practices of pattern searching and the interpretation of these patterns by means of deeper principles. In film studies, for example, scholars have developed precise methods for analyzing a film by integrating insights from semiology, literary studies and linguistics. We see this perhaps most clearly in the work of Christian Metz (1931-1993), who developed his "Grande Syntagmatique," in which he called the building blocks of film *syntagmas*. In the spirit of Noam Chomsky's generative syntax (Chomsky 1957), Metz designed a number of theoretical principles to create a hierarchical organization for these syntagmas so that the cinematic structure of the film as a whole could be visualized and interpreted. Such a cinematic narrative structure is represented by a tree diagram where the leaves of the tree represent film scenes and the branched structure reflects the relationships between the scenes (see figure 3).

Figure 3: Christian Metz's "Grande Syntagmatique"



From: Buckland 2000, 115.

This formal, principle-based analysis into building blocks has led to some surprising results. For example, the narrative structure of the popular series *CSI: Crime Scene Investigation*, which has dragged on for years, has been found to consist of only eight narrative building blocks that are endlessly reshuffled (Löwe, Pacuit, and Saraf 2009). This kind of narrative modelling thus uses an intermediate representation: the tree diagram.

It often occurs, however, that films, as well as novels and other narratives, cannot be represented by a tree diagram. This happens when narratives are neither linear nor tree-branching, but form a network that fans out and consists of a multiplicity of junctions without a clear beginning or end. Such a concept of an interwoven structure was articulated by Gilles Deleuze and Félix Guattari, who introduced the term "rhizome" to this end in *Mille plateaux* (1980).[12] The term rhizome is taken from botany, where it refers to an underground, usually horizontal, stem that often bends upwards again and thus creates a new

[12] For an English translation, see Deleuze and Guattari 2004.

plant. A rhizome is more complex than a hierarchical tree structure used in, for example, stemmatic philology. In a rhizome the different parts that are split up hierarchically in a tree structure can also be directly connected to one another. In mathematics and information technology, a rhizomatic structure is covered by the concept of *graph*.[13] Thus the structure of a website or a video game cannot normally be represented as a linear or hierarchical structure but as a rhizomatic one. Both tree-diagrams and rhizomes are models in the humanities that mediate between patterns and their underlying principles.

5. Humanistic versus Scientific Modelling

While modelling in the long-term history of the humanities may seem quite different from modelling in the sciences, we find some commonalities as well. Our notion of modelling in the humanities is in fact analogous to the notion of modelling in Mary Morgan's and Margaret Morrison's influential work *Models as Mediators* (1999). According to Morgan and Morrison, phenomena in physics and economics can usually not straightforwardly be derived from underlying theories, but need to be connected by external models that serve as a kind of mediators. Their notion of linking between phenomena and theory in the sciences by means of models makes a strong analogy with our notion of linking between patterns and principles.

There is an important difference as well. Morgan and Morrison exclusively focus on models as external representations of the objects or phenomena under study. We have seen that such a notion of model is not valid for all humanities disciplines. In many of these disciplines, modelling consists of describing the steps needed to link patterns to principles. While some humanities disciplines do indeed use external representations such as trees, graphs or rhizomes to link patterns to principles (see above), other disciplines use procedures, rules or constraints to do this job. Thus models in the humanities can consist of either internal representations (like a set of rules for deriving the archetype of extant texts) or external representations (like a tree diagram for analyzing a film). But regardless of whether humanistic modelling makes use of internal or external representations, the main goal of linking patterns to principles is to explain, understand and interpret the expressions of the human mind.

My quick overview of modelling in the humanities has of course only scratched the surface. The exploration of different methodologies, strategies and practices in the humanities has just begun. But it has led to new questions, such as: what is the epistemological place of the notion of pattern or regularity in the humanities and how does it differ from the sciences? How can we under-

[13] See Chartrand 1985. See also Moretti 2005.

stand the relation between the unique and the general? And how can singular events that are not part of a pattern be modelled in the humanities (see also the discussion below)? What we need to properly deal with these questions is a new discipline that we would call *History and Philosophy of the Humanities* (HPH), which should operate on par – and possibly in close alliance with – the already existing *History and Philosophy of Science* (HPS).

6. Discussion

Question (Fotis Jannidis): How do we reconcile patterns and the unique in the humanities? What about practices that are not defined by an interest in looking for patterns?

Answer: Indeed, as I have stated in the introduction, not all practices in the humanities are defined in terms of patterns and principles. But it should be kept in mind that patterns are not in opposition to unique events. Patterns actually consist of unique events or artefacts, and a unique artefact can often (but not always, as we will discuss below) be connected to underlying principles as well, so as to explain, understand, interpret or criticize that artefact. Take as an example the field of art history (but any other field would do): according to Wölfflin (see above), Baroque paintings share a certain common pattern, that is, they can be understood in terms of a number of stylistic principles typical for that style. But this also means that a single, unique Baroque painting can just as well be described by these principles: as a singular Baroque painting it shares common features with other Baroque paintings. At the same time, the art historian may be interested in the differences between the singular painting and other Baroque paintings (e.g. by highlighting the uniqueness of Caravaggio's style), but in all cases the art historian will have to refer to the particular Baroque pattern (and possibly the underlying principles). Thus even if one is interested in studying a single painting or literary work or musical piece, one may still use patterns and generalized principles in order to interpret a single artwork. And this is what I have called modelling.

Question (Fotis Jannidis): But how do we deal, then, with exceptions that do not fit patterns?

Answer: This is an interesting issue, especially if we consider exceptions that neither fit a pattern nor connect to underlying principles. As I said above: while modelling is found in all humanities disciplines, it is not the only practice in the humanities. Nevertheless, the problem of dealing with exceptions is found in almost all knowledge-making disciplines. And yet, common wisdom has it that the essential difference between the humanities and the natural sciences lies in the notion and treatment of exceptions.[14] The statement that "the exception proves the rule" seems unthinkable in natural science – although we should stress here that in the humanities this pronouncement is mainly used in the prescriptive tradition of secondary school grammars. All the same, there are most certainly exceptions in the humanities. However they are not solely to be found in the humanities, but in the natural and social sciences too. Theoretical physics, with its universal laws, is sometimes referred to as the only exceptionless discipline. This may represent a possible demarcation. Yet this demarcation characterizes not so much the difference between science and the humanities, as between theoretical physics and other fields. While theoretical physics permits no scope for exceptions, applied physics is full of ad hoc corrections, phenomenological constants, normalizations and so-called provisos. Although the universal laws of nature are considered to be exception-free, in mathematical derivations and explanations of specific phenomena ad hoc approximations and corrections are used more than once.[15] We cannot assert anything other than that there is a gradual scale from disciplines with the least exceptions to those with the most. While theoretical physics reflects an ideal picture, it is not feasible for most natural sciences, such as biology, geology, forensic science and even chemistry, let alone for other academic areas.

In the humanities there is such a gradual shift from almost absolute sound shift laws in linguistics to less absolute harmonic rules in musicology to changeable culture-specific patterns in history. But there is also a gradual shift like this in the natural sciences – from the absolute laws of theoretical physics to the more approximate laws in chemistry to the local and variable patterns in biology. The eminent biologist Ernst Mayr contended that universal patterns do not exist in biology (1997, 62). Mayr admitted that the laws of physics and chemistry of course apply to biological systems at a molecular level. In a complex system, though, no biological regularity has ever been observed that complies with the rigorous definition of a "law" in theoretical physics. According to Mayr, what biologists mean by a "law" is a pattern that is usually local and not universally valid and is moreover often statistical. These regularities are widely used in the modelling of biological phenomena, without their being reduced to the fundamental physical or chemical laws.

This brings me to another issue, namely the notion of autonomous levels of explanation, which I take from the philosopher of science Philip Kitcher (1984). In biology the set of principles and explanations used at cell level is different from that at an ecological level, for instance. This does not exclude the reduction – sooner or later – of complex biological processes to physical ones. However, it does not always make sense to reduce a biological phenomenon to the "deepest" principles of elementary particle physics in order to ex-

[14] For an overview of this discussion, see Bod 2013a, 356-8.
[15] For an overview, see Cartwright 1983.

plain and understand it. In line with Kitcher I would argue that there are also autonomous levels of explanation, understanding and interpretation in the humanities, which have their own set of principles, just like in biology and other disciplines. Obviously the laws of (particle) physics also apply to the human brain, and therefore also indirectly to the products of that brain, and thus to humanistic artefacts. Yet it is not the case that we need to consult biology or physics for the modelling of humanistic artefacts like a literary work, a painting or a piece of music. The cognitive and neurosciences have produced important insights into the study of literature, art and music,[16] but it becomes impossible and even senseless if we try to explain, understand or interpret a play by Shakespeare, a painting by Rembrandt or a symphony by Beethoven in terms of the sum total of all brain activities relevant at the time. It proves to be the case that autonomous principles of literary, artistic and musical analysis deliver the most insightful interpretations.

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Modeling in the Digital Humanities: a Research Program?

Fotis Jannidis [*]

Abstract: *»Modellierung in den Digital Humanities: ein Forschungsprogramm?«*. The term modeling is used in so many different research fields that the assumption that they are all conceptually connected seems quite hard to defend. Therefore, any research on modeling in digital humanities probably has to work inductively, to collect examples of all these different practices, in order to determine which have essential communalities. The formal modeling of research data in the humanities, up to now most often just discussed under a technical perspective, seems to be a good starting point for this endeavor.

Keywords: Data modeling, concept analysis, formal modeling.

1. Model and Modeling

It has been acknowledged that modeling is at the core of the digital humanities (McCarty 1999, Flanders and Jannidis 2015),[1] but the vagueness of the term has proven to be challenging for any attempt to build on this insight. Therefore, I will start out with investigating which concept of modeling and which of its features could be fruitful for the digital humanities. Let us start with a definition of modeling which is general enough to include some of the very different contexts the term can appear in:

> a model is a representation of something by someone for some purpose at a specific point in time. It is a representation which concentrates on some aspects - features and their relations - and disregards others. The selection of these aspects is not random but functional: it serves a specific function for an

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[1] This short essay picks up some threads, which have been started as part of a collaborative effort. Together with Julia Flanders I organized a conference on data modeling in the digital humanities which resulted in a white paper on the topic: Flanders and Jannidis 2015. We also edited a volume on data modeling which will be published in 2018 (Flanders Jannidis 2018). After so many discussions I am not able to claim any of the thoughts in this essay purely as my own.

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individual or a group. And a model is usually only useful and only makes sense in the context of these functions and for the time that they are needed.[2]

Models are usually expressed in some medium, they are representations. That is one of the reasons why many insights from media studies about mediality or from semiotics about signs can be applied to them. Models are not the modelled object itself, so for some aspect and under some perspective they will always distort some information, which is the basis for the famous dictum "all models are wrong".[3] But though this can be dramatized, usually this is not a problem for a successful use of a model. Comparing models to reality, one will always find some difference which can be seen as a deficiency, but this usually neglects the functional aspects of models. The importance of the relation between a model and its use cannot be overstated, because the functional requirements a model tries to fulfill are defined by this relation. Last but not least it seems useful to me to include the group which will use the model into our model of a model. This allows us to see models in a pragmatic context and distinguish between semantic aspects of a model and the details of its use.

Because this is still very general, it may help to have a closer look at what has been called a model *in research*. The term is used in natural and social sciences and the humanities to refer to the general theory, the theoretical framework behind our research, like the "standard model in particle physics" or the "theory of modernization". Or we can use it to refer to some specific part of the general model, which we want to investigate in detail, for example the Higgs boson or the establishment of a self-sustained social system like the judicial system. To be able to do research we need an operationalization, such as the experiment in the Large Hadron Collider with the collisions between protons, or the collection of historical material to show that, according to some defined indicators, there is a judicial system and it is – in some sense – self-contained. And for this part, the operationalization, the term "model" has been used too.

There is the whole field of mathematical modeling which is used at many different levels. I just mentioned the cases whereby a model is defined as a "purposeful representation of reality", usually to describe deterministic or stochastic processes of some sort.[4] These kinds of models, which are also used by those disciplines in the humanities which work with statistics, are obviously not the same as the models we see in machine learning which are used to classify or cluster data. There is, however, a relation between the two kinds of models.

2 See Jannidis and Flanders: A Gentle Introduction to Data Modeling. In: Flanders and Jannidis 2018. This definition is based on Stachowiak 1973.
3 Cf. Box 1976, 791-799.
4 Mooney and Swift 1999, 1.

And there is another very common use of "modeling" in the humanities: when we classify an item, thus ascribing it to some class, we often refer to the classes as models. For example, if we discuss which period a literary text should be ascribed to, it is generally assumed that the periods in question are some kind of model. In the context of computer science and DH this model is sometimes called an ontology.

In the field of research, the term modeling generally refers to many different activities, so different indeed that the question has to be asked: Can we learn anything of interest, when we ask the question "what is modeling?" Or is it more productive to discuss specific activities of modeling like theory building, hypothesis creation and testing, operationalization, mathematical modeling, machine learning models, classification and ontology creation etc.? All these activities, it could be argued, are connected by a family resemblance and focusing on this may shed some light on the term modeling. It is part of the definition of Wittgenstein's concept, that the first and the last member of the family don't have to share a common trait, they have nothing in common (Wittgenstein 1976). So looking at them will provide no deeper insight into the family.

It seems to me that the situation with the concept "modeling" is very similar, maybe even worse: the term presupposes a unity, some connecting band between its different uses, but in contrast to the famous example by Wittgenstein, the term "game", "model" is not used for a group of different activities in ordinary language, but for different activities in different disciplinary terminologies: mathematical language, language of computer science, language of machine learning, language of philosophy etc. Trying to understand what modeling is, we can collect all these different uses in specific terminologies and thus create the impression of some unity, some shared sense of the word, but probably it is a questionable endeavor.

In that light we probably should change the question and choose a new line of inquiry. If modeling is a cover term which refers to very different activities in different specialized contexts, what would be the best way to learn more about them and how can their role in the digital humanities be understood? If all these fields of modeling are important for the digital humanities, which of them are especially important?

For quite some time, certainly more than three decades, the answer was: *data modeling* is especially important. Developing and applying data models for cultural heritage has been and still is a core activity in the DH community. Digital representations of cultural heritage objects were assumed to have a much longer lifespan than many other digital objects and the modeling was either done in the context of institutions which are used to think in very long time spans or it was at least influenced by this context. So, data modeling was not only a technical problem to solve, but also an institutional problem: how to keep a data model alive? And a social problem: how to build a group of people, a community of users, around it?

There seems to be only one element which distinguishes modeling in the humanities from modeling in the *digital* humanities:[5] the need to formally model the data and at least some aspect of the phenomenon which is researched. So the role of formal modeling in modeling in the humanities in general and the relation of the formal model to the phenomena in the humanities are specific to the digital humanities.

Data modeling is a kind of *formal* modeling of entities and their features and relations. For institutional reasons it is still a relatively under-researched field in computer science because there the term "data modeling" is mainly understood to be the creation of a schema for a relational database. In my opinion data modeling is a cover term for a whole range of different "meta models" like relational databases, XML, graph theory, formal grammars etc. and we have no clear understanding of how these "meta models" can be described using a unified approach based on set theory and logic. To elucidate these connections and develop this unified approach seems to me to be an important step in building a theoretical foundation for what is nowadays very often approached as a practical engineering problem.

Because there is no general theory of the (digital) humanities, there is no way to develop a theory of modeling in the digital humanities using a deductive approach. So at the moment at least, we have to work inductively and collect insights into the features and problems of modeling in this context and maybe, at some point, we will be able to identify some general patterns. Working from top down, from the abstraction to the concrete ways of modeling, expecting to see some common traits will probably not work for the reasons given above. On the contrary, we have to assume that there are no common elements. But looking at them and trying to understand their specific challenges in the digital humanities seems to me to be an interesting research program. At the very end, there will be no grand theory of modeling, but we will have a deeper insight in, for example, the challenges historical artifacts, intentional objects, pose to all these different ways and levels of modeling. We will understand how the vagueness of historical knowledge is processed in these contexts, or how the alterity of historical objects is handled.

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[5] Maybe it is worthwhile pointing out that I am using the term "digital humanities" as an hyponym to "humanities", so any DH research is a case of research in the humanities. This has the maybe surprising effect that even some very technical development of methods in the DH is research in the humanities.

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Models and Modelling in Archaeology

Oliver Nakoinz *

Abstract: *»Modelle und Modellierung in der Archäologie«*. Being a discipline in-between natural science and humanities, archaeology has conflicting attitudes towards models. On the one hand the term model is currently very fashionable, while on the other hand there is a certain ignorance and even rejection of models in archaeology. This is caused by limited knowledge on models, the polarization of assumed paradigms, and different developments in different sub-communities in archaeology. Models in archaeology range from conceptual social models over typo-chronological models, regression models, network models and 3d models to simulations. One single definition of models seemingly does not work in archaeology, whereas a structured set of different terms based on an overarching definition of models would make sense. Since most models in archaeology are derived from other disciplines, the field would benefit from a trans-disciplinary modelling framework to enable efficient knowledge transfer. In order to establish a fruitful application of diverse modelling frameworks in archaeology, the establishment of disciplinary modelling communities together with a trans-disciplinary modelling community, as well as a proper education in modelling concepts and techniques, is required.

Keywords: Modelling, model, archaeology, theory, method, simulation.

1. Introduction

1.1 About Fashions

"This is just a model!" is a frequently heard statement in archaeology. It indicates a rather negative attitude towards models. Models are something of low quality, are rather hypothetical than being proper knowledge, and are inaccurate, positivistic, and at best a nice visualization.

On the other hand, "model" and "modelling" are fashionable terms in archaeology. Graphs of the key word "model" used in combination with a number of disciplines in the catalogue of the Library of Congress in Washington visualises the increasing popularity of the term (Fig. 1). While models became fashionable in mathematics in the late 1950s, caused by the introduction of digital computers and Tarski's English publications on models, it took another

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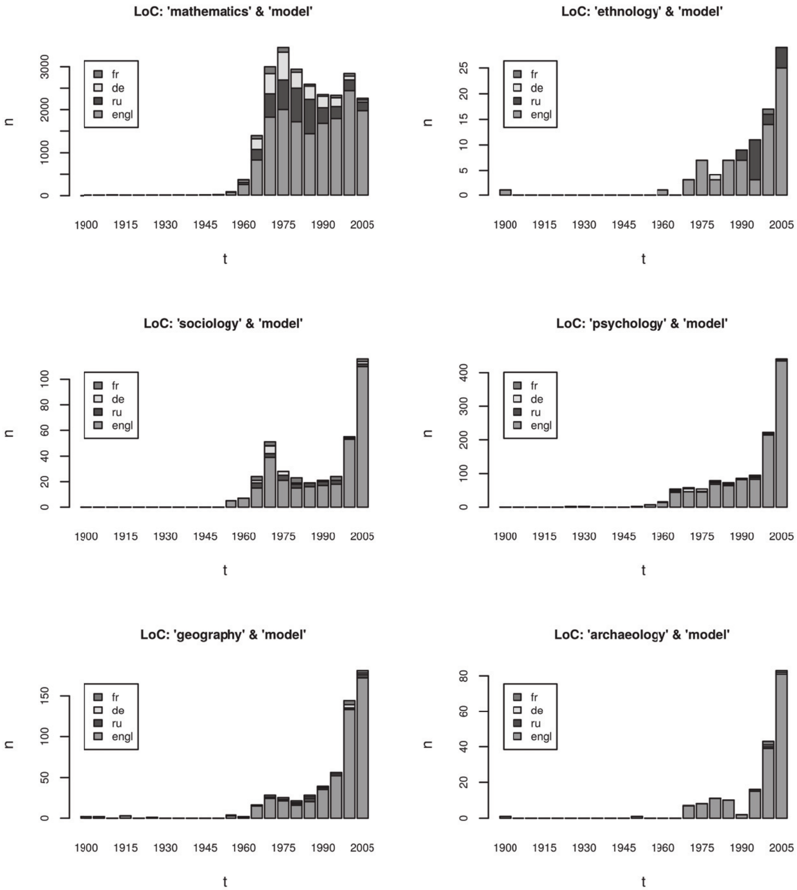
decade for the trend to keep up in other disciplines. In archaeology, geography, sociology and ethnology a first modelling hype took place in the late 1960s and early 1970s, followed by a phase of avoidance of the term "model" in the 1990s. In the late 1990s a second modelling hype started, which is still ongoing. Today modelling is at the same time very fashionable and much criticised.

The trendiness of a term does not say anything about the actual importance and usage of a certain concept but rather reveals something of the driving social processes of science.

Figure 1: Frequencies of the Key Word "Model" Occurring in Combination with the Name of a Discipline in the Catalogue of the Library of Congress in Washington



Source: Nakoinz and Knitter 2016, fig. 1.1.

1.2 About Paradigms

In the 1960s and 1970s archaeology was attracted by concepts adopted in natural sciences, which influenced the development of the so called "New Archaeology", a flavour of archaeology which stresses approaches in the natural sciences, quantitative methods, objectivity, mathematical concepts, structures and functions, modelling, and anthropological analogies. New Archaeology aimed to replace the cultural historical paradigm and was itself replaced by "Postprocessual Archaeology", a postmodern flavour of archaeology. Postprocessual archaeology focused on meaning, subjectivity, interpretation, individual decisions, semiotics and theory. New Archaeology and Postprocessual Archaeology have been some of the responses to a general development, to which the rise, the decline and the revival of modelling in archaeology are also due. There is no paradigm succeeding the post-processual paradigm. "Officially" we are still in the postprocessual period, but the word counts of "model" reveal that the "ideological power" of this paradigm has decreased and perhaps, unnoticed, reached the status of an integrational paradigm.

Before we are able to assess any paradigm, we need to discuss the role of archaeology as a discipline in-between natural sciences and humanities. It is obvious that archaeology is one of those disciplines in-between natural sciences, social sciences and humanities, such as geography and sociology. In particular, it seems that archaeology is alternating between the two extremes of the natural sciences and the humanities. But what exactly is the problem of the divide between science and the humanities? According to Snow (1960) the two communities are just not able to communicate. This is certainly a serious problem, but not the main problem for archaeology. The main difference between science and the humanities is that science follows an approach to knowledge which defines meaning based on structures observed in nature, while the humanities follow an approach to knowledge which negotiates pre-existing meaning. Archaeology starts with the humanities. We know something about human beings and ask questions about historical events and social structures. Our data derived from archaeological finds do not have meaning attached to them, they just have assumed meaning. However, in archaeology there is the need to switch to concepts of the natural sciences. We use the natural sciences as the source of specific data such as environmental data, but the crucial point is that we need to analyse the structure of the archaeological data with scientific concepts in order to reveal the meaning of the objects. At the end of this analytical process archaeology can switch back and answer the historical questions.

1.3 About Integration

This description shows that for archaeology to alternate between the humanities and science in the evolution of the discipline rather than within specific research projects is rather problematic. Only half of the research agenda of archaeology can be completed by adopting exclusively one of the two approaches.

Both "paradigms", New Archaeology and Postprocessual Archaeology, propagated paradigm shifts *sensu* Kuhn (1962). These paradigms do not correspond exactly to a scientific or a humanities approach, but there is a certain correlation. While New Archaeology tends to ignore the need of the humanities, Postprocessual Archaeology tends to ignore scientific methods.

There are at least two levels of complementarity, the one concerning scientific and humanities approaches, and the one related to preferred topics of New Archaeology and Postprocessual Archaeology. This complementarity clearly shows that the idea of paradigm shifts is rather absurd in this case, since they are not incommensurable "paradigms". Since the publication of Kuhn's book (1962), paradigm shifts have become tools for stimulating a researcher's career. The conjuncture of models in archaeology has to be seen in relation to this social and historical background. The arguments and discussions on models are hence partly based on the actual content being discussed and partly on ideology in connection to certain assumed paradigms.

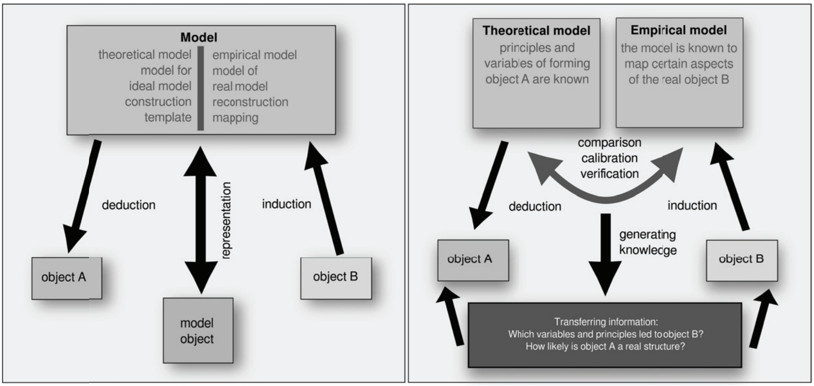
2. Different Types of Models and Terms in Archaeology

In addition to the confusion based on the "war of paradigms" mentioned above, archaeology features a rather wide range of different kinds of models. Due to the fact that archaeology needs to borrow methods and concepts from other disciplines, the variation of models in archaeology matches the number of disciplines it borrows from. For most types of models rather small communities exist which deal with these models. A lot of work is invested in working implicitly or explicitly with models, but although the term model is fashionable, it is generally assumed that modelling does not yet play a central role in archaeology as a whole. A modelling community covering models in general does not yet exist, while communities working on predictive modelling or network modelling are quite active. Below we will explore different types and terms of models.

One of the first explicit contributions to a kind of archaeological theory of models is David L. Clarke's article "Models and paradigms in contemporary archaeology" in his edited volume "Models in Archaeology" (Clarke 1972). He characterises a model by four terms: comprehensiveness, predictiveness, efficiency and accuracy. This makes it clear that he had a certain type of model in mind concerned with prediction. Considering that his friend Peter Haggett co-edited a volume on models in geography (Chorley and Haggett 1967) and was deeply involved in locational theory, this is not surprising. This friendship is responsible for most of the archaeological understanding of models during the following decades. The general idea was: to establish a relation between some parameters based on theoretical considerations; to use one parameter to predict the other one; and test the model with additional empirical observations. Clarke (1972, 3) writes that "Hypotheses are generated from the model expression of a theory. Explanation comes from tested hypotheses". A well-known use case of this approach is predictive modelling in archaeology (van Leusen et al. 2005).

This concept reduces models to some pure theoretical construct. This is still a valid concept for a certain part of the archaeological community, although the idea of distinguishing theoretical from empirical models (Mahr 2004) is more convincing and is currently spreading (Fig. 2; Nakoinz and Knitter 2016). Theoretical considerations can be used to construct a theoretical model. This can be compared with an empirical model based on empirical observations. When the empirical models fit the theoretical one, the theoretical considerations can be transferred (under certain conditions) to the empirical ones and new knowledge emerges.

Figure 2: Empirical Models, Theoretical Models and the Transfer of Information



Source: Nakoinz and Knitter 2016, fig. 2.5.

The work of Herbert Stachowiak on models was very influential in Germany and is also used in archaeology (Lemmen 2015). His definition, based on systems theory, is long and hence rarely cited. Stachowiak's characterization of models includes the three terms mapping, reduction and pragmatic, and is very comprehensive. We can translate this characterization into a definition: a model is a simplified mapping for a special purpose. This approach covers much more and also includes empirical models. An advantage is that this approach is not focused on prediction.

The meaning of the term model is usually not based on a coherent theory but on a common understanding in different discourses and contexts. There is a certain meaning of model, which can be connected, for instance, to model railways for children and diorama or ship models in museums. While this concept is covered by Stachowiak's approach, it does not agree with Clarke's approach. 3D models of landscapes and archaeological documentation represents another, though related, understanding of the term model. Both types of model represent real world objects in order to show them as substitutes for the original. This approach can include the reconstruction of parts of objects.

The next category are models producing new information. Simulations are similar to empirical models, but they use artificial data produced according to the rules of theoretical models. Monte Carlo simulations and agent based models (Kohler and van der Leeuw 2007), for instance, are used in archaeology. For some archaeologists model is a synonym for simulation.

While simulations involve a random component, deterministic models produce definite results according to the applied rules. A frequent example in archaeology are Voronoi graphs, which produce exact borders between territories. Usually these lines are considered unrealistic and, without a comparison with an empirical model, this approach does not give much insight. With respect to concerning the real world representation of the model, conceptual modes are less strict. The social rank model for Iron Age Scandinavia (Fabech and Ringtved 1991), for example, distinguishes three social ranks which are connected to certain types of artefact. The model establishes certain ideas about the relationship between the members of these ranks. Conceptual models in general define the relationship between different entities and are also used in practical archaeology. Examples are the definition of workflows and the structure of organizations, as are database models. Conceptual models based on high level theories and concerned with the ancient world can be distinguished from those based on low level theories, which are concerned with the research process.

A rather important type of model, though they are rarely addressed as models, is the latent model (Nakoinz and Hinz 2015). Latent models represent the idea of certain relationships between entities, which tend to be implicit in many approaches and is rarely expressed explicitly. The typo-chronological model can serve as an example. The idea that artefacts of the same type are from the same period and similar types are from a similar period is the main assumption of the typo-chronological concept. This is nothing but a regression model formulated as a conceptual model, which has been used as a hidden assumption for many chronological considerations during the last two centuries.

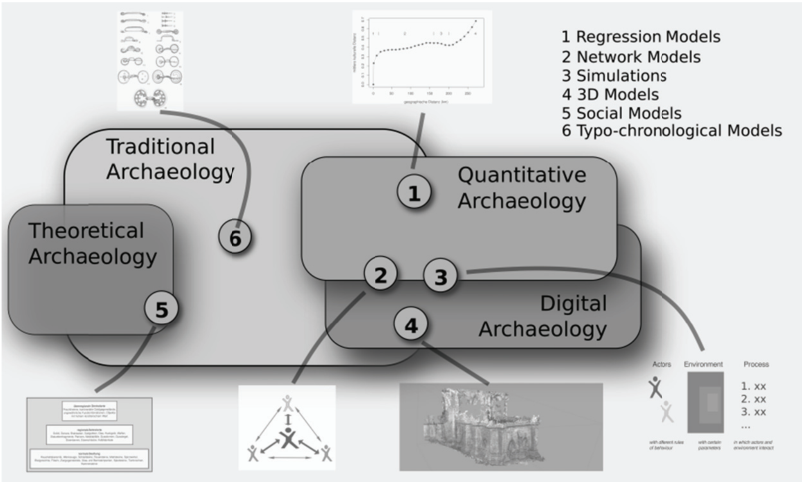
Although examples of predictive models, such as Voronoi graphs and simulations, have been given above, quantitative models shall be mentioned as a category in its own right. The main idea of quantitative models is to establish or apply the relationship between different parameters using mathematical constructs. Frequently used methods are regression, interpolation, cluster analysis, correspondence analysis, and similar approaches. Classical interaction models mapping the intensity of interaction against the distance of interacting partners can serve as an example (Nakoinz 2013, 2014). Another well-known example also imported from geography is the gravity model (Diachenko and Menotti 2012).

The term model is not used with the same intensity across all of these flavours of models. A laser scan of an archaeological site would be called a model, while traditional documentation, comprising drawings, photos, and descriptions, which in fact produce a kind of empirical model, is not considered a model. The frequency of the use of the term model is much higher for predictive modelling and quantitative models than for conceptual models such as data models. Therefore, the frequency of the use of the term model reflects the history of research with a certain bias. The use of the term model starts, in archaeology, in the 1960s and reaches a peak in the 1970s, due to the success of New Archaeology. The nadir of occurrences of model appears in the 1980s and 1990s because of the postprocessual critique which made use of different types of models while consistently avoiding the term model. Since the end of the 1990s, the usage of the term model has been increasing.

Currently, different kinds of models are in use in archaeology. The main categories are: predictive models, representative models, simulations, conceptual models, quantitative, and latent models. The different classes of models in archaeology are connected to different terminologies, and some are not even referred to as models at all. Different communities use different types of models for different purposes, based on different assumptions and the adoption of different terminologies. A definition of model or even a theory of model is required, which considers the social component of modelling and addresses the hidden assumptions. This idea is not only emerging from archaeology. In Kiel, the computer scientist Bernd Thalheim established an interdisciplinary group of researchers interested in models. This group developed a bottom up approach to modelling theory which solves some of the problems mentioned above (Thalheim and Nissen 2015). A model is defined as an artefact representing a part of the world. There is an analogy between model and original. A model is used in a certain community of practice as a tool for a certain purpose. Each community of practice shares some assumptions around the models it adopts, methods for developing and using models, and ideas for validating them. The shift of focus from the methodology of modelling and representative objects toward a practice of modelling in a certain community certainly supports the formation of a general theory of models as well as a common terminology in archaeology.

This short survey of the field of archaeological models reveals a heterogeneous set of models connected to different sub-disciplines and fields of research. Figure 3 is an attempt to locate different concepts of models in a disciplinary set diagram. Social models are placed in the field of theoretical archaeology, while typo-chronological models belong to traditional archaeology. Network models and simulations belong to both quantitative archaeology and digital archaeology. Regression models are associated with quantitative archaeology, while 3D models belong to digital archaeology. This distribution is due to the different foci of the very tightly related sub-disciplines of quantitative and digital archaeology.

Figure 3: Examples of Models in Different Sub-Disciplines of Archaeology



Although there is a certain degree of overlapping and double membership, the different sub-disciplines still have their own communities. In particular, there are very few people who would claim to belong to the theoretical archaeological community as well as to the quantitative archaeology community. The reason for this separation of communities is of course the polarization of presumed paradigms.

3. Reasons for Using Models in Archaeology

The advantages of using models are obvious and as heterogeneous as the types of models themselves. Models and modelling are important not as objects, nor as methods, but as conceptual frameworks for handling knowledge, covering theory as well as practice. Models provide a structure for using and communicating comprehensive knowledge, inside and between disciplines. They provide a certain degree of abstraction, which makes it easier to establish connections between different theories, methods, and applications. In particular, models make it much easier to bridge the gap between science and the humanities, because they strip off the knowledge which is important for the different communities but which is not necessary for dealing with a certain topic. Since archaeology is a discipline in-between science and the humanities, this bridging function is particularly promising for the advancement of the discipline. Models stimulate the creative process and give fast access to a certain topic? Models allow archaeologists to play with different points of view and to combine different ideas with nested models.

4. Conclusion

4.1 Which Term for Model?

Does it make sense to ask for a general definition for models, which covers all disciplines? The case of archaeology with various models borrowed from different disciplines shows the difficulties of developing a general definition of models. In addition, reducing the heterogeneity and using a specific term for models would minimise the integrative power of the model approach. A general term for models would, however, establish a basis for common understanding and communication. On the other hand, a very general definition, covering all possible types of models, would lack the precision required for many modelling tasks.

It is possible to benefit from both, the lack of an overarching terminology and the specificity of modelling practices at the same time. This requires a very open and general terminology for models to be subdivided into specific terms for different types of models. We already have a lot of specific terms for models, but we lack an accepted general terminology and in particular we lack a structure which establishes the connections between the different specific terms for models, a kind of family tree of models. In addition we lack the acceptance of specific terms for models used by diverse communities, since most communities assume that they are in possession of the right, most general and meaningful definition.

4.2 Four Levels of Using Models

In addition to problems with the definition of the term "model", we have to face the fact that there are some completely different ways of using models. We can define four levels of using models:

1. Models as Ontological Objects

The wax-model of a prehistoric man as it is exhibited in a museum and treated as an object representing another one might serve as an example. Constructing a model means producing an object which resembles something else and can be used to represent the original object. A model is used to communicate features of the original object by showing some similar features to its audience. The mapping or analogy is the key feature for this approach.

2. Models as Epistemological Model-Objects

The shift towards an epistemological perspective allows us to focus on the process of deriving new knowledge from models. Constructing a model is to produce something which has certain properties. The models are mainly used for comparison and hence the reduction of the original information to a set of important elements is the key feature of models in this approach.

The reconstruction of prehistoric houses from one area can be compared with those from another area. Digital elevation models are used to understand the ancient topography of an archaeological site. Regression models are used to establish dependencies of parameters of the location of settlements.

3. Modelling as a Practice of Solving Problems

The shift to a practical perspective characterises this use of models. Constructing a model means taking something and using this construct as a model for a certain task. Anything can be used as a model, but it is required that certain activities, when using the model, allow the modeller to complete a certain task. The model can be used as a replacement for the original in order to explore internal mechanisms and external relationships. Models as tools or instruments which can be used for a certain purpose is the key feature of models for this approach.

Simulations of social or environmental processes help us to understand the nature and possible outcome of these processes. Which parameters are leading to which types of settlement patterns? Which activities are required to grow certain crops? Is a population of x individuals for a settlement a reasonable assumption?

4. Modelling is a Research Framework

Finally, the shift of focus towards the communities of practice using certain models facilitates the formation of a research framework. Which assumptions are made by the relevant community of practice? How do they construct and use models? What exactly do the terms used in this community mean and how do they differ from similar terms in other communities? How are the models understood inside and outside the original community of practice?

Comparing the empirical models of archaeological evidence with the theoretical model of building structures such as houses or graves allows archaeologists to interpret the original data. This is usually done in archaeology without a reference to models. The modelling approach offers a clear and concise terminology and even a workflow which enables researchers to involve colleagues from other disciplines and other regions without extensive training in the specific terminology in use.

All four levels of the use of models make sense for specific purposes and we should not assume that one level is better than others. It seems to be much more useful to find the right level for a certain objective. For instance, it does not make any sense to force all research into the "modelling as research framework" approach. This is certainly a concept from which many research projects can benefit, but for some research projects working in a well-established and efficient research environment without any need to communicate with other communities might reduce productivity and efficiency.

5. Perspectives

As long as "This is just a model!" is heard in archaeology, we are far away from a proper understanding of models and even further away from a fruitful adoption of models on a broad scale. Currently a rather small community in archaeology is working with different kinds of models and so contributing to modelling in archaeology.

In order to maximise the benefits of the modelling approaches in general and in archaeology, we need to complete some organizational, communicative and educational tasks:

1) Establishing a transdisciplinary modelling community. This community would ensure that knowledge transfer between communities is made possible. In particular, for archaeology, the exchange with other disciplines is essential. The present HSR Supplement as well as some other activities in recent years show that the development of this community is a work in progress.
2) Discussing a general terminology for models. Actually, it is not necessary to come up with a proper and universally accepted definition. Although it would be nice to have the perfect definition, the discussion itself develops transdisciplinary communication skills.
3) Connecting the different communities of practice to this transdisciplinary community. A small transdisciplinary modelling community without contacts to the disciplinary communities does not improve the scientific system as a whole. Since not all researchers can be involved in the transdisciplinary exchange, the communication between disciplinary modelling experts and transdisciplinary modelling experts is essential, in particular for the concept of modelling as a research framework.
4) Developing trans-disciplinary and disciplinary educational frameworks. The process towards modelling as a tool for trans-disciplinary communication and as a research framework starts with individuals, but needs to be based on the whole community. While the students of some disciplines receive a rather good education in modelling, an education on a trans-disciplinary level and in specific disciplines (such as archaeology) in still lacking. The basics of modelling must be part of the curriculum for archaeologists. This does not mean we must educate all archaeolo-

gists as modellers but it does mean we must ensure that everybody can communicate with modelling experts.

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EVERYTHING IS TRANSLATION (Including the Art of Making New Boots out of the Old Ones)

Gunnar Olsson *

Abstract: *»Alles ist Übersetzung (einschließlich der Kunst, aus alten Stiefeln neue zu machen)«.* Presented here is a map that does not look like a map but as a sculpture, a glass tetrahedron sunk into a square slab of granite, three gold threads and a red ruby; nothing less than an attempt to capture what it means to be human. A creation epic of our own time, a pictured story of how the semiotic animal – a species blessed with the faculty of imagination –sacrifices an original difference by turning into a set of alternative identities. All told, the intricacies of power-and-knowledge captured by the interplay of the Peircean signs of symbol, icon and index, the paradigmatic lines of power (/, —, =) embracing each other in a perpetual ménage à trois. Everything cast onto the culturally prepared projection screens of religion (ideology), the arts and the sciences. Ethics and aesthetics two sides of the same coin, the tetrahedron the most beautiful of all geometric forms.

Keywords: Imagination, geography and geometry, identity and difference.

Man dansar däruppe – klarvaket
är huset fast klockan är tolv.
Då slår det mej plötsligt att taket,
mitt tak, är en annans golv.
Nils Ferlin, "Infall"

Every modeler knows that the entrance to Plato's Academy was adorned with a well-wrought sign, at the same time inviting and forbidding. Not, as in the case of Auschwitz, *Arbeit macht frei*, but HERE NOBODY ENTERS WHO DOES NOT KNOW HIS GEOMETRY. The message was, of course, that the rules of geometry and the rules of thought are one and the same, the implication that whoever holds the keys to the former automatically knows the way also to the latter. Likewise, critics of cartographic reason believe not only that geography is best defined as a geometry with names, but that the Academy had both a public entrance and a secret exit. And next to that worm-eaten door was a penciled note: HERE NOBODY LEAVES WHO DOES NOT KNOW HER GEOGRAPHY.

Easier said than done. For whereas naming the cornered points is daily business, baptizing the lines (the relations between the points) is like chasing a chameleon, capturing the planes (the taken-for-granted projection screens onto

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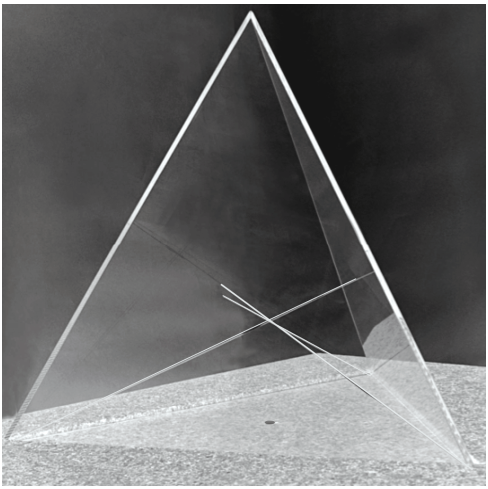
which the points and lines are cast) nothing less than a struggle with Gödel's impossibility theorem.

The roots reach deeply into the issue of what it means to be human, hence not only into Sophocles' *Oedipus Rex*, Plato's *Republic* and Aristotle's laws of thought but into the Ten Commandments as well. One could go crazy for less, especially as tragedy teaches that whatever fate there is we bring onto ourselves. To do otherwise would therefore be to be dishonest to one self, to break the rules of one's own game, to be utterly lost. In the long run that is impossible, for everyone is one with his own map, the indicative and the imperative thoroughly entangled. Beware, though, for just as geometry is a form of rhetoric, so geography is a form of imagination. No wonder that the map is such a power-filled creation, a flying carpet, the contraband par excellence.

And for that reason I must now briefly return to the sculpture *Mappa Mundi Universalis* (Olsson 2007, 412-437; Jensen 2012), in the same expression a mapping of power-and-knowledge and a self-referential presentation of the fix-points, sight lines, and projection planes of understanding, in every respect the joint effort of myself and my friend and former student Ole Michael Jensen. So close was in fact our cooperation that in the end we reported our findings not with our individual names but under the amalgamated imprint of Gunnael Jensson. Seemingly not a map at all, just a tetrahedron of transparent glass grown out of a square slab of granite.

Figure 1: Gunnael Jensson, Mappa Mundi Universalis. Glass Tetrahedron on Granite Base, 25 ´ 25 ´ 19¼ in. Mixed Media (Kalmar Granite, Weissglass, Gold, Ruby)



Source: Museum Gustavianum, Uppsala. First Exhibited in the Uppsala Cathedral, September, 2000. Photo by the Artist.

Not much, yet enough to last us for a lifetime.

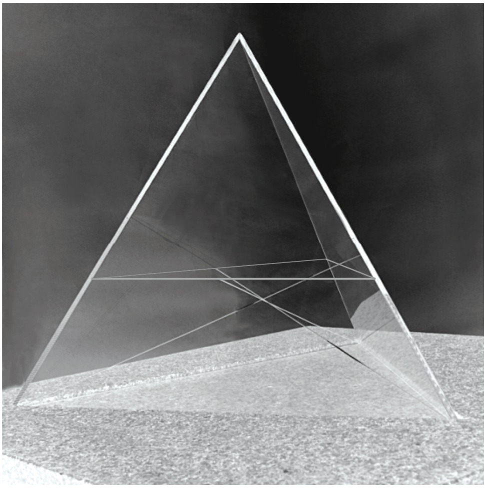
To understand why, imagine how a long time ago a drama was set in motion. The stage-floor is a flat rock that gently slopes into the sea, the actors some strange creatures emerging out of nowhere, aimlessly spreading across the homogeneous plain. A foot gets stuck in a crevice and for the first time ever there is a difference different enough to make a difference. The others notice, they point and they mutter, every gesture an attempt to force the bothering difference into graspable identity. An event of tremendous consequences, for what we are now about to witness is the very first sacrifice, *the* act through which the indefinable creatures are eventually changed into human beings, a species whose individuals are held together and kept apart by their use of signs, every sign an ironic expression of Signifier and signified merged into one (Olsson 1993; Jensen 1993).

When the difference is pulled out of the rock, a well of blood springs up, a constant reminder of what happened when the original deviance was turned into a non-willing scapegoat, the baring of the navel of what it means to be human. In the materialized version of Jensson's sculpture the place of this remarkable event is marked by a red ruby, a godly symbol which in the accompanying text is called **A**. Not because it *is* **A** but because as semiotic animals we must call it something.

In the definitional struggle that now follows, the mute difference is transformed into a set of communicable identities, like every translation an act of violence. More precisely, the foot in the crevice splits into a trinity of reformulations, a set of provisional reincarnations that in the chaos of mimetic desire find their positions in the corners of an equilateral triangle. Each of these aliases is then given a name that reflects the pain with which it was born: the shadowy **a**; the tautological **a=a** alternatively the perfect sign $\frac{a}{a}$; the informative **a=b**.[1]

[1] Rephrased, the unknown **THIS** is captured in one of the alternative nets of **this**, **this is this**, and **this is that**, the **this** closely related to the slanted line of dialectics (**/**), the this is this to the horizontal line of the Saussurean Bar (**––**), the this is that to the parallel lines of the equal sign (**=**).

Figure 2: Mappa Mundi Universalis with the Prophets' Ceiling and the Peoples' Floor



As the initial difference is sacrificed, atoms of understanding are captured in a mushroom cloud of perpetual fission.

When the tension reaches its limit, the rock bursts and out of the lava grows a glass tetrahedron, a crystal palace sometimes known as the crucible of man, sometimes as the prison house of language. The floor and the three walls of this enchanting structure are all built as equal-sized equilateral triangles, the walls transparent, the foundation sunk into the granite ground, the ruby-covered well at its center. In a twist of cultural survival, the three reformulations (**a,** $\frac{a}{a}$**, a=b**) now rise from the base, stretch upwards and meet again at the tetrahedron's top, the multitudes of Greek polytheism converging in the singularity of Abrahamic monotheism. Like every mapping, also this one is a triangulation, the **A** and its three restatements coming together in the vanishing point of the pinnacle, the locus of a tautological entity that by definition is what it is – [**(a) / (** $\frac{a}{a}$ **) / (a=b)**] – not merely a contradictory condensation of Aristotle's difference and identity, but a transcendence of the law of the excluded middle, in its totality nothing less than a rephrasing of God's name (*if a name it is*). And from its inception this Absolute speaks. *Let there be!* And there is. A universe flowing out of the creator's mouth, in James Joyce's conception a commodious vicus of (p)recirculation.

In the coolness of the evening, the utterer (also known under the tautological pseudonym **A=A**) listens back to what he has heard his tongue say, claiming first that it is very good, then that he alone has the right to judge. Tolerating neither idols nor false prophets, he declares that all usurpers will be killed and that every critique will be censored. Hereafter, there shall be neither pictures nor stories, hence no maps either. Impressed by his own achievements, he then proclaims a day of rest, a Sabbath without work, twenty-four hours devoted to the glorification of himself and his faithful. Mandatory presence, no excuse accepted.

Such is the subjection of subjects. Such is the structure of power. Such are the techniques by which we are made so obedient and so predictable. The three (or is it four) words of Moses' first stone tablet (*the* prototype of constitutional law) in its eternal context.

The crystal palace is a well-guarded castle, its ruling resident the tyrant of tyrants. Admittedly a rhetorical exaggeration, for no Absolute is absolutely absolute, no crook crooked enough to live on forever.

But the palace is also a marvelous movie theater, one projector in each of the basement corners, golden rays carrying the alternative translations from the machine rooms to the screens of the opposite walls: the limestone wall of Plato's cave; the wood panel of Fra Angelico's *Annunciation*; the glass of Marcel Duchamp's *La mariée mise à nu par ses célibataires, même*; all found again in the *mappa* of cartographic reason. And when the projections of the imagined identities hit the sheets of glass they miraculously change into a set of Peircean signs, no longer the private fantasies of their inventor but communicable bits in an evolving discourse. To be technical, the **a** becomes the symbol of *a*, the **a=a** the icon of $\frac{a}{a}$, the **a=b** the index of *a=b*. But just as the painter's canvas must be properly prepared for the paint not to crack or run off, so must our minds be indoctrinated to ensure that all that is solid does not melt into air. Three grand institutions have risen to the task: religion (the / with its belief in the *a* of shared conventions), art (the — with it's $\frac{a}{a}$ striving for perfect resemblance), science (the = with it's *a=b*, the as-if of provisional truth). Each mode of understanding entrenched within its own self-supporting power structures, rules, and regulations.

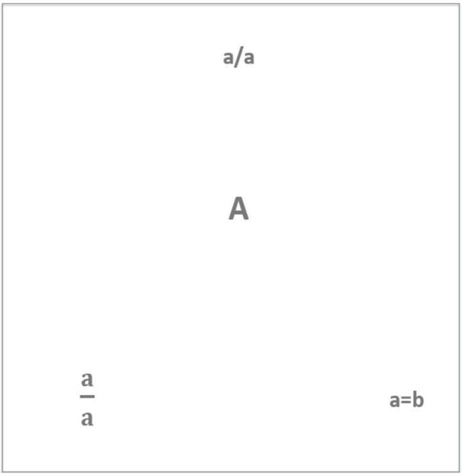
If these rituals could be perfectly performed, then the projection lines would strike the screening planes at 90o angles, every message going straight back to the cornered restatement it came from, nothing learned in the process. But even though the Saussurean/Lacanian sign is steeped in mimetic desire, the diverse ontologies of Signifier and signified guarantee that this perpetual urge can never be satisfied. Hence the fortunate consequence that no translation can ever be perfect. It follows that in actuality the inclination of the (en)lightening rays is never *right on* and that the projections, instead of returning to the original identities unchanged, start bouncing between the walls. In turn, this slight deflection means that whatever I happen to think, say and do is never pure and simple but always a non-dissolvable blend of religion, art and science. And suddenly I see where the trigger of tragedy lies: in the purifying spirit of the right angle, in the hatred of the other which is built into the desire of every identity formulation – the iconoclastic controversy, Hitler's *Lebensraum*, Stalin's *Gulag*, Rwanda, Srebrenica – all variations on the same theme of translation. Out of bounds. Murderous is our history, murky the connections between Signifier and signified, knowledge and action,

In turn, this is why tragedy for forty years has occupied such an important place in my own conception of what it means to be human, indeed why I take it to be the most insightful of all available conceptions of thought-in-action and action-in-thought. The original setting is crucial, for Sophocles – a Janus-like figure who with one eye was scanning the old, with another imagining the future – lived his long life in the abyss between the *mythos* of Homer and the *logos* of Plato. What he then discovered was that the greatest tension of his time lay in the attitudes to predicament, for while the archaic poets had taken a person's social standing to reflect his or her ability to handle contradiction, the new philosophers defined paradox as the greatest threat to the cohesion of human reason, an enemy to be fought by all means. As Wittgenstein ([1921] 1961) later put it, "without philosophy thoughts are, as it were, cloudy and indistinct: its task to make them clear and to give them sharp boundaries" (4.112). But in Sophocles' eyes religion was itself nothing but a human invention designed to keep people in place, like other laws issued by the humans of the polis rather than the gods of Olympus.

In my mind this pre-Christian circumstance explains both why the tragedians assigned such a crucial role to the chorus and why the recurring convulsions of the last centuries are essentially a political crisis, an orgy in promises that cannot be kept and therefore should never be given, the election results bought with junk bonds issued in the voters' own names. Whereas the problem for the tragedians was the exact drawing of the boundary between the humans and the gods, the problem for the post-democrats is that although all animals are equal, some pigs are more equal than the others.

In my reading it is exactly these relations between religion, arts, and science that are brought to life in the imaginary space of Jensson's Prophets' Hall, its floor located on the same level as the intersection of the right-angled projection rays and its ceiling supported by the Peircean signs of symbol (*a*), icon ($\frac{a}{a}$) and index ($a=b$).

Figure 3: Traces of the first sacrifice



A most remarkable event, for without these signs there would never be a semiotic animal blessed with the faculty of imagination, by definition the ability to make the absent present and the present absent – nothing less than the birth of what it means to be human, the blood-stained embryos from the original sacrifice cast onto the reflecting walls, the Hall itself (a fusion of Plato's cave and the Sistine Chapel) turned into a picture gallery, a staff of prophets serving as expert guides – Pope Francis and Karl Marx, Albert Einstein and Alan Turing, Paul Cézanne and Marcel Duchamp presently foremost among them.[2]

And what do the prophets tell me? That for my own sanity I should leave this echo chamber where I do not belong and proceed to the next floor of the Plotinian house, a hypostatis where I might better understand what it is to be human. Accordingly I now find myself in an enchanting Hall of Mirrors, a

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[2] Fastened to the wall of religion, but like the other paintings flowing over to the nearby ceiling, are Mark Rothko's large canvases, thin layers of red upon red, many appropriately titled Untitled, by all indications the artist's way of capturing the breathing *a*, his subsequent suicide a foregone conclusion. Moving on to the wall of art we are then directed to a ceiling of orthodox icons (including Kazimir Malevich's *Black Square* and his *Suprematist Composition White on White*); to the non-initiate a set of mysterious pictures of the holy, to the believer something holy in and of itself, hence the very essence of the tautological *a=a* and the Saussurean *aa* Finally the wall of science and the Peircean index *a=b*, in the ceiling shown as a montage of the expression $E=mc^2$ flipping first into the atom bomb and then into the double helix declaring that I am what I am, uniquely different from everyone else, the original sacrifice in reverse. And at the nave of it all are Michelangelo's nine scenes from the Book of Genesis, *The Creation of Adam* the most famous among them.

place better known as *The Peoples' Ball Room*, its floor tiles made of solid oak fetched from the Kantian Island of Truth, its ceiling one with the upper limit of language. Centrally placed in that room (its architecture a blend of the stately Versailles and a folksy amusement park) is a platform with a throne reserved for the ruling ruler and a stage set aside for the entertainers, the sommeliers, dance bands, clowns and jugglers, all of them cogs in the propaganda machine – bread and circuses, panem et circenses. And even though the children in the gutter keep shouting that the emperor is naked, the lackeys continue to carry the trail that does not exist.

Much can be said about the Ball Room happenings, not least about the dialectics of one and many, truth and trust, knowing and believing, power and submission, law and order, terror and unpredictability, touchable things and untouchable relations, the five senses of the body and the sixth sense of culture – every conversation a medley of mixed metaphors, every exchange an exercise in translation. Looking back at my own work I can now see that I have been spending half a century in this fascinating space, an epistemological adventure well captured by the titles of the three books *Birds in Egg/Eggs in Bird* (1980 [1975]), *Lines of Power/Limits of Language* (1991), and *Abysmal: A Critique of Cartographic Reason* (2007). In the present context there is little to add except that already the preface of the *Abysmal* (ix) confesses that "the present volume may be read as a record of the silent conversations I have subsequently had with [the Jensson sculpture], this material expression of desires non-suppressed." Yet I am astonished to see how the once lonely Ball Room is getting crowded with a group of trend setters, Giorgio Agamben, René Girard, Bruno Latour, Peter Sloterdijk, Slavoj Zizek presently most noticeable among them. So tell me now, you mirrors on the wall, who's the fairest of us all?

Searching for an answer I lift my eyes. And when I do, I see that above the Hall of Mirrors there is a mezzanine, by no coincidence located exactly midway between the well in the granite basement and a replica of the Nicaea palace at the tetrahedron's top. A crawling space filled with the implements of ontological transformations, including not only the glue of the copula (usually symbolized by the parallel lines of the equal sign), but also the paper-thin wands of the Divided Line of Plato's *Republic*, the Bar of Saussure's *Cours de linguistique générale* and the coolers of Duchamp's *La mariée mis à nu par ses célibataires, même* (the clothesline on which the bride hangs her white garment and the artist his uncolored self-portrait); the paradigmatic lines of power (/, –, =) embracing each other in a fascinating *ménage à trois*.

Stuck in that in-between space, a place that feels more like an attic than a balcony, I am overwhelmed by the roar of thunder and hammering of heavy rain, everything accompanied by the music and stomping feet of a fiddler on the roof.[3] Nothing less than the third Commandment confirming itself, six days of work and one day for honoring whoever broke your chains and brought thee out of Egypt (Deutoronomy 5, 12-5). Serious business, for most exegetes agree that the Sabbath was as unique an invention as Israel's worship of one single god, hence a crucial part of the socialization processes through which we are made so obedient and predictable. As the musical has it, "like the drip, drip, drip of the raindrops, when the summer shower's through, so a voice within me keeps repeating you, you, you. Night and day you are the one, only you beneath the moon and under the sun" (Porter 1932).

Fiddling is the fiddler as untouchable ideology is stirred into a concoction of material things and social relations. Abrakadabra, simsalabim! Pogroms in the making.

In the history of *longue durée*, these musings deserve little but a footnote. Yet they too spring from the tension of trust and verification that lies at the heart of European culture, perhaps of all cultures, the tales about Oedipus' foot and Odysseus' scar pulling in one direction, the paragraphs of Moses' first stone tablet in the other (Auerbach 1953). In the cleft in-between hides the *inter esse* of everything inter-esting, including the scientist's testable theory and operationalized model, in the same breath a reified deification and a deified reification, the potentially informative **a=b** turning into the tautological **I am who I am**. In that context the lawmakers' grasp of human action as a magic game of ontological transformations is truly remarkable:

> Thou shalt not make unto thee any graven image, or any likeness of any thing that is in heaven above, or that is in the earth beneath, or that is in the water under the earth; Thou shalt not bow down thyself to them, nor serve them (Exodus 20, 4-5; Deuteronomy 5, 8-9).

Well decreed. For in the empirical now-here of the utopian No-where, nothing is more inhibiting than our inability to be abstract enough, presently a threat to our very survival. As Abraham responded on his way to the *akedah* (Genesis 22, 1): "Here I am." And the two went on together, world literature's most pregnant silence, translation at the edge. H.C. Earwicker (also known as "Here

[3] To my astonishment I also notice that the roof is leaking, the water almost certainly coming from the point where the invisible pillar that stretches from the **A** in the palace basement to the **A=A** of the godly penthouse breaks through the Ball Room ceiling. At issue is the alternative interpretations of this hol(e)y place, in the *Mappa Mundi Universalis* baptized **A=B**, by some congregations revered as "Mohammed" by some others as "Jesus Christ", the former a reporter of what he has heard, the latter the incarnation of what he has been seen to be. A universe left to explore, a *Mappa Mundi Nicaenum* on its way to the drawing board. For just as mapping is triangulation, so triangulation is a geometry of power. And just as the geometry of power is the practice of cartographic reason, so the practice of cartographic reason is the critique of mapping (Olsson, 2007, p. 434). And so it is that the Nicene Creed is a codification of a belief system as power-filled as anything ever chiseled onto the first stone tablet, as logical as anything ever uttered in the Greek Academy. Astonishing is the richness of the tetrahedron, often called the most beautiful of all geometric forms.

Comes Everybody" and "Haveth Children Everywhere") in search of himself, the cobbler as well (Joyce 1939).

Boot for boot, difference for difference. And Babble's walls come trumping down.

Discussion

My Answers to Claas Lattmann's Questions

In his insightful discussion Claas Lattmann noted the connections between my *Mappa Mundi Universalis* and Plato's *Republic*. His remarks were highly appropriate, for while in my mind Plato's dialog is in fact a map, its overriding purpose to charter the way to the good life in the good city, my crystal palace is an attempt to grasp how the semiotic animal straddles the abyss between identity and difference. In both cases an illustration of how we are relying on the faculty of imagination to make sense of the world.

To be more precise, the connections to the allegory of the Cave are striking, even though my attention focuses more on the cave wall than on the performing puppeteers or the chained prisoners. The reason is, of course, that without the projection screen of the wall, there are no shadows either; in the *Mappa Mundi* the three screens of religion (/), art (—), and science (=), serve exactly the same purpose. Even more immediate, though, are the parallels to the Plato's Divided Line, in my case often symbolized by the fraction line of the Saussurean Bar, the latter nothing less than the magic wand of human action: Let there be! And there is. The Swedish epigram speaks for itself, here literally and without the rhymes: They're dancing upstairs / wide awake is the house. / Then it suddenly strikes me: / my ceiling is someone else's floor.

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Iconizing the Digital Humanities. Models and Modeling from a Semiotic Perspective

Claas Lattmann[*]

Abstract: *»Die Ikonisierung der Digital Humanities. Modelle und Modellierung aus einer semiotischen Perspektive«*. Models are ubiquitous in the digital humanities. Against the backdrop of the recent discussion in the philosophy of science about what models are and what they do, this paper presents a semiotic perspective on models in the framework of Charles S. Peirce's theory of signs that sheds light on the practice of modeling in the digital humanities. As a first step, it is argued that models are icons, i.e. signs that represent their specific objects by being regarded as similar to them; and that there are, in all, three basic types of model, namely "images," "diagrams," and "metaphors." A second step explicates relevant implications of this model-theoretic approach, especially as they relate to the digital humanities. In particular, it is shown that models are not identical to the things they represent and that they only represent them partially; that the representation operates on the basis of a mapping relation between select properties of the model and its object; that each model and each instance of modeling has a theoretical framework; and that models are the true basis for genuine creativity and progress in research.

Keywords: Models, icons, images, diagrams, metaphors, C. S. Peirce, Digital Humanities.

1. Iconic Perspectives on Digital Humanities

Modeling is as ubiquitous in the digital humanities as it is in today's scientific research.[1] Scholars use models for creating an ever-growing number of computational tools that expand the breadth and depth of humanities research. The traditional objects of study are transferred into the digital realm by being "modeled" by computers so that computations can be done that provide new and, if possible, exact insights. Modeling in the digital humanities opens up

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1 Models play an ever-growing role in contemporary science: see Bailer-Jones (2009) and Frigg and Hartmann (2017); cf. Thalheim and Nissen (2015a) with case studies from a diverse range of research fields. On models in the digital humanities, see McCarty (2005, 20-72), and Ciula and Marras (2016); for a general perspective, see Schreibman, Siemens and Unsworth (2004, 2016).

new avenues of research and at the same time reshapes the way scholars do their investigations.

This computational turn, or at least digital expansion of traditional methodology, takes place all over the humanities and, to a varying degree, affects all fields of study, both in research and in teaching. In particular, this holds true for Classical Studies, an area that was among the first to embrace the digital age.[2] To give just a few examples, scholars of Greco-Roman antiquity have created digital 3D models of ancient buildings;[3] interactive mapping tools to explore ancient landscapes and travel routes;[4] network models of the axiomatic-deductive relations among proofs in ancient mathematics;[5] models of the materiality of the medieval manuscripts that contain the ancient texts;[6] models of citation networks of references to ancient texts in modern scholarly literature;[7] large-scale databanks that contain analyses of the syntactic structures ancient texts exhibit;[8] digital editions of Greek and Latin texts;[9] and corpus-

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2 For the early development of computational approaches in Classical Studies, see Solomon (1993); for a more recent account see Crane (2004). One of the first and most long-lived projects in the digital humanities is the "Thesaurus Linguae Graecae" (TLG), a databank of ancient Greek literature that began in 1972 (<http://stephanus.tlg.uci.edu>); for a history of the project see Thesaurus Linguae Graecae (2017). Another long-lived project in Classical Studies is the "Perseus Digital Library," which began in 1985 (<http://www.perseus.tufts.edu>); its core is a large-scale collection of texts and other testimonies from ancient Greco-Roman culture, including pictures of material remnants and scholarly literature. Interestingly, the systematic use of models in order to acquire objective, "scientific" knowledge seems to have been invented in ancient Greece itself; see Lattmann (2015). In any case, the first attestation of a word for model, "*parádeigma,*" belongs to an inscription in the so-called Tunnel of Eupalinos on the Greek island of Samos, which was built in the 6th century BCE; see Käppel (1999).

3 E.g., of the Athenian Acropolis: see Tsingas (2012). Cf. The Digital Institute for Archaeology's "The Million Image Database" project (<http://www.millionimage.org.uk/>).

4 Cf. the "Ancient World Mapping Center. 'À-la-carte'" project that allows the GIS-based creation of custom maps for ancient Greece and Rome on the basis of historical cartographic material (<http://awmc.unc.edu/awmc/applications/alacarte/>). For the modeling of ancient travel routes see, e.g., "ORBIS: The Stanford Geospatial Network Model of the Roman World" (<http://orbis.stanford.edu>). Cf. interaction models as described by Nakoinz (2013); see also Nakoinz and Hinz (2015).

5 Cf. Schiefsky (2007).

6 Cf. Campagnolo (2015).

7 Cf. Romanello (2016).

8 Cf. the efforts relating to building large-scale treebanks, with the goal of creating a basis for comprehensive computational linguistic analyses: see, e.g., the "Ancient Greek and Latin Dependency Treebank (AGLDT)" (<https://perseusdl.github.io/treebank_data/>) project that was started in 2016; cf. Mambrini (2016) and see Bamman and Crane (2010, 2011).

9 See the "Homer Multitext" project (<http://www.homermultitext.org/>); cf. Crane (2010) and Almas and Beaulieu (2013). Often these editions allow various analyses of the textual material; cf. the "Digital Athenaeus" project (<http://digitalathenaeus.org/>) that aims at providing the tools for analyzing text reuse and sources of quotations; for the latter, cf. Bozia (2016), Celano, Crane and Majidi (2016), and Gorman and Gorman (2016). For another

based digital lexica that use sophisticated statistical methods.[10] Despite the apparent diversity of these tools that provide new perspectives on, and methods for investigating, the traditional objects of research in Classical Studies,[11] it is clear that they are nothing but, or at their core rely upon, digital versions or "models" of those objects proper which they are meant to stand for.[12]

As essential as models are for the digital humanities, they are not mere tools that do not exert any influence on what scholars are investigating. Quite the contrary, models shape what we see to a considerable degree, and it is arguably the case that they even determine what we *can* see. For example, if we create a digital political map of ancient Greece, by investigating this model we might only find out what the borders of the Greek states were, but we cannot discern, e.g., which cultural relations existed between the single parts of Greece, beyond and independently of the political landscape; moreover, this model might be understood as implying that there actually was something in antiquity that was identical to "borders" in the modern sense. To give another example, if we model ancient travel with direct distance as the only criterion for choosing routes, we cannot see that the primary factor in making a travel decision might instead have been the travel costs in terms of time and expenses.[13]

In principle, it is not the original, "real" object that we access in the digital humanities, but a substitute, i.e. the "model," which we ourselves create, explore, investigate, and manipulate. But how exactly do digital models relate to their original objects? What are the conditions under which we may use them? What are, after all, the advantages and disadvantages, the limitations and benefits of models? In view of the ever-growing importance of digital models in the

example, see Bernstein, Gervais and Lin (2015); cf. the "Tesserae Project" (<http://tesserae.caset.buffalo.edu/>).

[10] See, e.g., Bamman and Crane (2009), in particular for their discussion of some of the differences in scope and method when compared to traditional lexica, such as the standard "Greek-English Lexicon" by Liddell et al. (1996 [1940]).

[11] Another example of how digital technologies might change traditional research and teaching is the "Perseids" Project, which is nested into the "Perseus Digital Library" and implements crowdsourcing approaches: cf. the project homepage (<http://sites.tufts.edu/perseids/>) and see Almas and Beaulieu (2016).

[12] Cf. Ciula and Marras (2016) as well as McCarty (2004) who locates "modelling" at the core of the digital humanities and contends that it "points the way to a computing that is *of as* well as *in* the humanities: a continual process of coming to know by manipulating representations." However, McCarty's position differs from the perspective taken here insofar as he sees modeling only as a heuristic tool and "essentially a quest for meaningful failure": "The best model of something, that is, comes as close as possible to what we think we know about the thing in question yet fails to duplicate perfectly that knowledge" (both quotes McCarty (2003, 1232)). For a more in-depth discussion of this position, see McCarty (2005, 20-72).

[13] See Scheidel (2014) on the rationale of the "ORBIS: The Stanford Geospatial Network Model of the Roman World" project (<http://orbis.stanford.edu>).

humanities, it is of paramount importance to be able to give sufficient answers to these questions.

Seldom though do the practitioners of the field seem to be interested in exploring such abstract and at their core philosophical issues.[14] To a certain degree, this is to be expected and, admittedly, justified, for modeling is an inherently practical activity and as such it does not necessarily require that we have a sophisticated theory of models. Moreover, there is a confusing variety of model-theoretic approaches in the scholarly literature from divergent and often incompatible perspectives.[15] In consequence, it seems to be all but impossible to adequately define and comprehensively explore the notions of "models" and "modeling," even if only in order to sharpen our methodological toolkit for practical purposes.

This situation should not be surprising. Apparently, it is caused by the specific nature of the subject matter itself. As the small number of examples of digital models in Classical Studies given above already suggests, it does not seem to make much sense to try to apply the label "model" to all the divergent things that are commonly called "model." After all, there does not seem to be "the" model, but only "models," and this only in a very loose sense; after all, it is hard to see what all these "models" could have in common. What, for example, does a digital map have in common with a treebank; or what does a bibliographical model have in common with a 3D reconstruction of an ancient temple or a robot model of a Roman gladiator? Apart from being something "digital," there does not seem to be any single characteristic property (or set of properties) that these things share with one another. The word "model" might just be a highly polysemous word so that the search for a general theory of model might be futile and, in any case, not worth the effort.

This paper disagrees. It will, first, sketch an answer as to whether there is a universal definition of model that covers all the models used in the digital humanities (and beyond) in the affirmative.[16] This model-theoretic approach operates in the semiotic framework of Charles S. Peirce's theory of signs and proposes that models are a specific form of sign, namely icons, i.e. signs that

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[14] However, cf. McCarty (2005, 20-72). To be sure, the situation is similar to that in theoretical science: see Gähde and Hartmann (2013).

[15] For an overview, see Bailer-Jones (2009), Frigg and Hartmann (2017), and Frigg and Nguyen (2017); for a brief account of the history of model theory, see Morrison and Morgan (1999b). Cf. Thalheim and Nissen (2015b, 2015c) as well as Nissen and Thalheim (2015a, 2015b, 2015c).

[16] I have put forward this model-theoretic approach together with Björn Kralemann elsewhere; here I can only present the outlines of this theory and, especially in section 3, point out some ramifications for our understanding of digital humanities as a genuinely model-based field. For a fuller account, see Kralemann and Lattmann (2013a, 2013b) and cf. Lattmann (2012, 2015, 2016); cf. Gallegos (2018). Nonetheless, I will take the opportunity to more fully explicate some of the relevant implications of this approach, especially as they relate to modeling in the digital humanities.

are defined as being similar to what they represent.[17] A second step will trace relevant implications of this understanding of models that will provide insights into what we can and cannot hope, and try, to achieve by modeling and thus in digital humanities at large. This section will demonstrate that it is not only possible to give a universal definition of model, but that it might also be helpful to do so.

2. Iconizing Models

Modeling is an essential feature of using computers as a research tool, whether in science or in the humanities. In order to compute anything, one has to build and use models that resemble those things outside the computer about which the sought-for computations shall be made, whether these things are physical objects or theoretical concepts or whatever else.[18] The inherent reliance of computing on models is readily apparent at the higher levels of computing, for example in object-oriented programming languages, for they are based on the idea of modeling software objects that are, due to some sort of similarity, regarded as equivalent to things existing in the "real" world, here those things scholars are interested in investigating in the first place, such as the original Greek and Latin texts themselves.[19]

It directly follows that digital models are categorically different from their original objects and, in principle, not identical to them. Rather, they stand for

[17] There are certain similarities to other approaches that understand models as signs in the framework of Peircean semiotics; cf., e.g., Ljungberg (2016). Among the main differences, though, are the following two points: here, the notions of model and icon are strictly identified; and second, other model-theoretic approaches are integrated into the overarching semiotic framework. These are, first, the model-theoretic approach of modern logic (see, e.g., Balzer (1997); cf. Hodges (2013); for an account of its earlier development, see Chang (1974) and Vaught (1974)); and second, those model-theoretic approaches that describe models from the viewpoint of the concept of mapping (see, e.g., Stachowiak (1973); cf. Giere (1999, 2004), Suárez (2003, 2004), Frigg (2006)).

[18] For clarity's sake and to avoid misunderstandings, it is important to stress that the notion of "reality" shall be understood in a broad sense as implying that something has the capacity of actually affecting and/or acting upon another thing. In the terms of Peirce's theory, this amounts to something's being a phenomenon of "secondness." The intricate question, though, as to what "'reality" exactly meant for Peirce has been controversially discussed; for some insights see Mayorga (2007) and cf. below.

[19] This is the case even at the most basic level of computing, for the electric states of computers represent, and stand for, those numbers (etc.) that make up the relevant (abstract or specific) data structures (etc.). That computers have a basically semantic (or semiotic) nature is evident in view of the general characteristics of the Turing machine, as which each computer can be described, for the two core components of the Turing machine, "program" and "data," are conceived of as categorically separate, with the "data" by definition having a "symbolic" (and that is semiotic) nature; cf. Barker-Plummer (2016).

and "represent" these objects as their ontologically separate substitute in the digital realm.[20] Insofar as representations are nothing but signs and signs can be investigated via semiotics, the general theory of signs, we have to take a semiotic perspective and explore models as signs. For this aim the sign theory developed by the American philosopher Charles S. Peirce is well-suited, especially because it is embedded in a comprehensive and powerful epistemological framework.[21]

What then is a sign? Peirce defines it as "something which stands to somebody for something in some respect or capacity" (Peirce CP 2.228), that is, a sign is conceived of as something that is an element of a relational structure that is established by an intentional action, that is, by someone's *using* something as a sign. Anything can (and does) act as a "sign" if and insofar as, for some person (or, more generally, entity that is capable of establishing a sign relation, including computers) it represents some "object" and, to continue quoting Peirce's definition, "creates in the mind of that person an equivalent sign, or perhaps a more developed sign," the so-called "interpretant" (Peirce CP 2.228).[22]

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[20] For clarity's sake, I should stress that a representation does not necessarily need to be (whatever that means) "realistic" or "naturalistic," e.g., as one might conceive of a photography. If something represents another thing, this just means that, in someone's judgment, the one thing stands for the other thing. Evidently, this can be the case even if there is no resemblance at all, such as when we use the demonstrative pronoun "this" in order to deictically point to something. On the other hand, neither a representational nor a similarity relation implies that one of the relata must be a simplified version of the other; for this widespread view see, e.g., McCarty (2004). In effect, models can be as complex as their original objects and maybe even more complex; for example, an exact replica of a human being could be classified as a model, even if under most circumstances it probably might not be a very useful one for research purposes.

[21] This is not meant to imply that there are no other sign theories. Quite the contrary. However, taking Peirce's theory as the basis for formulating a model-theoretic approach is justified by the fact that it is sufficiently well-suited for describing models as representational (and thus) semiotic phenomena; and that it allows us to neatly integrate other model-theoretic approaches. For an overview of sign theories, see, e.g., Copley (2001); for more detailed insights into Peirce's theory of signs, see Short (2007), Atkin (2013), and cf. Colapietro and Olshewsky (1996).

[22] Cf. the full quotation at Peirce CP 2.228: a sign "addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the *interpretant* of the first sign. The sign stands for something, its *object.* It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the *ground* of the representamen." Cf. Peirce CP 1.564: "A representation is that character of a thing by virtue of which, for the production of a certain mental effect, it may stand in place of another thing. The thing having this character I term a *representamen,* the mental effect, or thought, its *interpretant,* the thing for which it stands, its *object.*" Cf. Peirce MS 318 (1907) where Peirce defines the object as the antecedent to the sign and the interpretant as the subsequent to it: "The object is what the sign finds; the meaning [or Interpretant] is what the sign leaves."

It directly follows that the things used as signs as well as their objects are, on the one hand, not confined to physical objects (i.e., *qua* physical object). Among other things, we can use words such as "unicorn" to let them stand for non-physical, abstract concepts and imagined things like a unicorn.[23] On the other hand, the notion of sign is not confined to "linguistic" signs either as they are commonly understood. For example, a wind rose can, by pointing somewhere, "stand for" and "represent" the actual direction of the wind at a given moment in time. By definition, anything can be a sign if and insofar as it is used to "stand for" and thus "represent" something else. Something being a sign is no inherent property of any specific thing, but belongs to, and is due to, the realm of semiotic practice.

In sum, Peirce's definition of sign provides a broad conceptual understanding of signs. They are not bound to any specific form of manifestation or medium. Not only words, but also images, sounds, feelings and so on can be used as and, thus, be signs. The definition of sign in particular applies to all those things that are commonly classified as models, among them smaller or larger replicas of things, mathematical formulas, computer simulations, and digital visualizations.[24]

Given the general definition of sign, though, it is obvious that models cannot be signs *simpliciter.* While it is clear that every model is a sign, there evidently are signs that are not models. For example, the word "word" is, when used as such, a sign, but it is not a model for anything, at least not for its meaning proper, "word." It follows that we have to determine whether there is any specific and clearly-defined sub-form of sign that can be called "model."

At first sight, this does not seem to be the case, given the vast variety of things that are called "models." This impression, however, is mistaken, for actually, there *is* one type of sign that can be identified with models, namely "icons." Icons are one of the classes of sign resulting from Peirce's exhaustive classification of all signs into the three classes of "icons," "indices," and "symbols" by way of differentiating the specific quality of the relation between the sign and its object.[25]

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[23] Of course, distinguishing degrees (or modes) of reality prompts quite intricate philosophical questions. As mentioned above, "reality" shall here just be taken to mean that, loosely speaking, something has an actual effect on something else; for this to be the case it does not matter what the specific mode of being of these things is. Cf. Peirce MS 339 (note of April 3, 1906).

[24] It should be stressed that all direct relata of the sign relation are signs; cf. Peirce CP 2.303 and see Peirce MS 318 (1907) and MS 339 (note of October 23, 1906). Signification, therefore, has a genuinely semiotic nature; cf. Peirce CP 1.339. A consequence is that we have to distinguish between different types of objects (two) and interpretants (three), explicating which aspect of Peirce's theory would lead too far here; for some details, see Jappy (2016).

[25] As according to Peirce CP 2.243, the basic criterion for this classification is whether "the relation of the sign to its object consists in the sign's having some character in itself, or in some existential relation to that object, or in its relation to an interpretant." It would lead

Let us briefly review these three types of sign in order to understand the specific characteristics of icons and, thus, models: first, a "symbol" represents its object by standing for it because of convention or habitualization. Examples are regular words, for they represent their objects because they are commonly used in order that they represent them. The word "word" stands for a "word" only because it has been made to do so at some point in time and people have continued using the word in that way ever since. Second, an "index" represents its object by standing for it because of an actual connection to it. A wind rose, for example, is an index that represents the direction of the wind at a specific moment in time, if and insofar as it is at this given moment in time actually affected by the wind. Third and finally, an "icon" represents its object by being regarded as possessing a similarity or resemblance to its object. It is defined as "a Representamen whose Representative Quality is a Firstness of it as a First. That is, a quality that it has *qua* thing renders it fit to be a representamen. Thus, anything is fit to be a *Substitute* for anything that it is like" (Peirce CP 2.276).[26] An example is a photograph, because it represents its object *qua* being supposed to be perceptually similar to what it shows and is therefore deemed fit for serving as a substitute for it.

Insofar as this classification of all signs into icons, indices, and symbols is exhaustive, it is not only the case that models must be classified as icons, but also that they have to be *identified* with them, that is, as long as we grant that they are "signs" at all.[27] But signs they are, because, evidently, insofar as models are "models," they are supposed to stand for or represent "something," that is, semiotically, an object. Furthermore, the relation between this object and the model must necessarily be conceived of as a similarity relation, because a model, first, does not have the primary purpose of showing that something exists or exerts an actual influence, as an "index" does; nor does the relation between model and object primarily exist because of an arbitrary or habitual connection between these things, as is the case with "symbols."[28] Rather models are supposed to directly "show" what they stand for and, accordingly, we

too far to explicate the intricate details relating to this classification; for some insights, see Peirce CP 2.247-249 and 4.447-448 and cf. Peirce CP 1.369. There are different (though not incompatible, but complementary) classifications of all signs according to different criteria; for a thorough and insightful discussion see Jappy (2016, 2017).

[26] This definition is based on Peirce's theory of categories; see, e.g., Peirce CP 1.417; 1.300-353; 1.545-567; and 7.327-332; as well as Peirce L 104 (1904). For the conceptual role of Peirce's three fundamental categories for the definition of sign, see Peirce CP 2.242.

[27] This is one of the main differences to approaches to understanding models from a semiotic perspective that have been put forward. Cf., e.g., Ljungberg (2016) who equates models with "diagrammatical models" exclusively (on this form of model, see below).

[28] That an icon (model) is defined as having a similarity relation to its object does not imply that the similarity relation itself is sufficient for letting something be an icon (model), *pace* Frigg and Nguyen (2017, ch. 4). It has been denied that models are necessarily similar to their objects, e.g., by Suárez (2003); on this position, however, see Poznic (2016).

want to "inspect" them in order to gain acquaintance with, and knowledge about, what they represent as well as use them as a more accessible "substitute" for their objects that mediates between theory and "reality."[29]

In effect, models are icons, and icons are models. We can further refine this insight by availing of Peirce's, once again exhaustive, classification of all icons into three separate classes (Peirce CP 2.277).[30] The criterion for this classification is the specific type (or "quality") of similarity that is involved in the iconic sign relation. There are exactly three types: in principle, a similarity can either relate to simple ("monadic") qualities, that is qualities as such, such as the quality an object has with regard to its color; or, second, to qualities that are expressible in the form of two-term (dyadic) relations, that is relations that have, according to Peirce, an "existential" or "real" nature and are supposed to actually belong to something; or, third, to qualities consisting of three terms, which are, according to Peirce, nothing but "semiotic" qualities, that is, qualities that involve a "sign" relation. Evidently, this differentiation is based on the minimal number of relata involved in describing the respective qualities, in accordance with Peirce's relation-based notion of category:[31] monadic qualities are what they are in and of themselves ("firstness"); dyadic qualities are what they are due to some form of pairwise or, in another word, direct interaction ("secondness"); and, finally, triadic qualities are what they are due to involving something that connects two other things ("thirdness"). The single relata of these relations, however, do not have to have a simple constitution themselves. For example, also a composite variegated pattern of different colors can be classified as monadic quality insofar as each partial color is what it is due to itself and not because it stands in a specific direct relation to any other color of the pattern.

The resulting types of icon/model are "images," "diagrams," and "metaphors":[32]

1) "Images" represent their objects by representing simple qualities of their objects by way of exhibiting equivalent simple qualities of their own. This could be, for example, photographs, toy models, or our perceptual content in general. "Images" therefore are not confined to *visual* images, despite their name. There are also audible images, tactile images, audible-tactile-visual images and so on; there is no restriction as to the medium (or media) in which these icons manifest themselves. "Images" as de-

[29] On models as mediators, see the essays collected in Morrison and Morgan (1999a), especially Morrison and Morgan (1999c); see also Blättler (2015).

[30] For a detailed explication of this classification, which Peirce only gives at this place in a notoriously dense and obscure formulation, see Lattmann (2012).

[31] On the notion of quality in general, see Peirce CP 1.422-6.

[32] See Ciula and Eide (2017) for an application of this classification to models in the digital humanities.

fined by Peirce, therefore, need not be image-like in the common sense at all.[33]

2) "Diagrams" represent their objects by representing dyadic qualities of their objects by way of exhibiting equivalent dyadic qualities of their own, that is qualities that can be described by way of direct or pairwise relations. Examples are mathematical diagrams as we find them in Euclid's *Elements,* for their representational quality is the sum of all the mathematical relations among its elements, but each of these elements has a specific direct relation to any other element of the diagram that can be expressed independently of the relations to all the other elements. For example, in a diagram that features a circle that is bisected by a diameter, the diameter has a specific direct relation to the circumference for which the specific direct relation of the circumference to, say, the center of the circle is of no relevance.[34]
3) "Metaphors" represent their objects by representing triadic, that is semiotic, qualities of their objects by way of exhibiting equivalent semiotic qualities of their own. An example is the metaphor "Achilles is a lion," in the framework of which sentence the sign "lion" is assigned an uncommon representational quality for what the name Achilles habitually stands for.[35] Insofar as metaphors necessarily involve another icon and thus model, they can be regarded as meta-models that allow us to experiment with the consequences of using something as a model for another thing, here of using the (image) icon implied by the symbol "lion" for representing Achilles.[36]

Of these three types of model, it is mainly diagrammatical models that are relevant in scientific and digital humanities research. In these contexts, models are often used to represent, show, and bring to light qualities that are supposed to be essential relational properties of their objects that belong to their "real" constitution. Accordingly, diagrammatical models are supposed to lay open the objective nature of things and, at the same, time make it accessible to direct perception.

[33] It is a pervasive feature of Peirce's terminology that he often uses traditional names for objects that he redefines in a most abstract sense, but for which the things denoted by the terms as commonly understood can serve as an example. As is obvious in the case of "images," this method can lead to severe misunderstandings, for it seems to be implied that this type of sign is restricted to only visual images. This impression, however, would be mistaken.
[34] See Lattmann (2018) for a model-theoretic analysis of those diagrams that were used in ancient mathematics and especially Euclid's *Elements*. Peirce's theory of the diagram has been subject to lively discussion in recent times, especially in semiotic studies; see, e.g., Stjernfelt (2007), Queiroz and Stjernfelt (2011), and Krämer and Ljungberg (2016).
[35] For an explication of Peirce's metaphor theory, see Lattmann (2012).
[36] Cf. Ciula and Eide (2017, i35).

However, as is the case with "images," the class of "diagrams" is not restricted to visual or even mathematical diagrams.[37] The notion of "diagram" includes any icon that is meant to exhibit dyadic relations. In particular, this also applies to mathematical formulas and most computer simulations, for they, too, directly represent and exhibit (and not only express or describe) quantitative direct relations that are relevant for what the respective things are supposed to be in "reality" (see Peirce CP 2.282 and 4.530). As such signs they are nothing but icons, even if they are composed of, and formulated by way of, "symbols," namely the mathematical symbols as defined by the theory of mathematics. Accordingly, a map can still be regarded as an icon, and especially a diagrammatical model, if it also includes the non-iconic conventional names of the places depicted on it graphically. In short, any representation acts as a "diagrammatical model" that is used to iconically make accessible some sort of (static or dynamic) "structure" (or "pattern") that a thing is supposed to have or show, irrespective of which semiotic nature its constituent parts have.[38]

Evidently, "diagrams" as defined by Peirce play a central role in research. However, the two other classes of model are important, too. On the one hand, "images" can, among other things, convey a (so-to-speak) first-hand impression of the objects of study, for example, small replicas or reconstructions of ancient buildings, such as digital 3D models. On the other hand, metaphors allow us to create new concepts and explore hitherto unknown areas, in particular by transferring ideas from one area to another by semiotically equating them on the basis of postulating that they are similar, in whatever way it may be. For example, the methods developed in Classical philology by Karl Lachmann and others for creating stemmata of texts for editorial purposes were fruitfully put to use in the middle of the twentieth century in a biological context for describing evolutionary processes in the then new field of genetics.[39] Given this, metaphors are one of the most fundamental bases of human creativity, and they play an important role in modeling, too, especially as heuristic tools in the context of exploring new fields of research.[40]

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[37] This is a most important point for understanding Peirce's theory of diagrams. Cf., e.g., Bechtel (2017) and Abrahamsen and Bechtel (2015) who, despite demonstrating the importance of diagrams for scientific research, presuppose that the notion of diagram is confined to (loosely speaking) visual diagrammatical (in the traditional sense) drawings.

[38] The equivalence (or at least, similarity) of the notions of "structure" and "pattern" in this regard might be particularly interesting from the perspective of the history of the humanities, which can be aptly described as a history of pattern-seeking: see Bod (2013a); cf. briefly Bod (2013b).

[39] For this example, see Bod (2015).

[40] This can already be observed at the beginning of Western science in ancient Greece: see Lattmann (2015, 2016).

3. Modeling Icons

In the final section of this paper, I want to point out some of the implications that follow from the understanding of models I have sketched in the previous section. In so doing, I hope to contribute to shedding light on the practical dimension of modeling, in particular in the field of digital humanities. In short, the train of thought is the following: (1) Models are not the things themselves; (2) from which it follows that models do not represent their objects completely, but in a complex way; (3) that is, in modeling we establish a mapping relation between the properties of the model and its object, which mapping relation depends upon a specific theoretical framework; (4) because of which models are not theories; (5) but nonetheless they are, due to the similarity to their objects, the only basis of genuine creativity and, therefore, progress in research.

(1) Models are non-identical to what they are a model of; they are not the things themselves. For example, a computer-generated 3D model of the Parthenon is not the Parthenon itself; a social network model of the Athenian elite of the 5th century BCE is not the historical social network itself; and a map of the ancient world is not the ancient world itself. At first sight, this seems to be a trivial point to make, but actually this is not so. We all too often forget that we are just investigating the model and not the original thing itself. The reason for this misapprehension is obvious: one of the fundamental presuppositions of modeling is that the model is similar to its object and therefore a well-suited substitute for it. But as similar as the model might be to its "real" object, it will in principle never be anything but a substitute.

This fact has far-reaching consequences, in particular with regard to the validity of the results that can be achieved by modeling: all the knowledge models can provide primarily and in principle relates only to the models themselves and not to their objects, that is, those things we are interested in investigating in the first place. Accordingly, models cannot provide *per se* true insights into these objects. Instead they provide only *potentially* true insights, which always have to be vetted and validated. The general way of doing so consists of, after having completed an abductive step by creating the model itself, a deductive step by which we explore what must be true if the results given by the model were true indeed; and an inductive step by which we check these implications against "reality" (amounting to some sort of "experiment"), that is, of course, as far as this is necessary and possible at all. This process might lead to a better model, if need be by iterating it until the model is judged to be sufficiently good enough.[41] Of course, especially in historical studies, one of the main

[41] According to Peirce, this is the general method of acquiring knowledge: Peirce CP 2.773-8; 2.641-4. Cf. Liatsi (2006) on the application of this method in historical and especially Clas-

problems and challenges consists in implementing the last, inductive step, given the scarcity of data as well as the fact that we can only use historical sources and are not able to do any direct experiments.[42]

(2) This leads to the second point. Because models are not the original objects themselves, but independent things of their own right that are intentionally used as “models” by treating them as similar to, and thus a substitute for, the original objects,[43] models do stand for, and represent, their objects, but in principle they do not do so completely. Instead they stand for their objects, as every sign by definition does, with respect to only select properties. For example, a treebank that consists of, and represents, sets of syntactical dependencies as they manifest themselves in ancient Greek sentences does, on the one hand, contain representations of the sentences themselves, but these representations only relate to their syntactical structure, and this without even taking into account their combination in texts beyond the single sentence. In view of this, it is in principle mandatory to always be clear about what a model is supposed to represent; in the case of treebanks, this would only be the syntactical dependencies the single sentences exhibit, not the sentences in their complete complexity or their comprehensive meaning in their pragmatic context etc.[44]

Furthermore, the fact that models represent their objects only with regard to select properties is not only a matter of including and excluding some of the properties in the model; in the process of modeling a more complex process takes place. For example, a political map of the ancient world and its semiotic object do not share the property of size; furthermore, the map displays properties that the original object does not possess, such as lines denoting borders; and it lacks properties that the original object does possess, such as the different heights of the terrain. Models, therefore, are not merely simplified, abstract versions of their original objects. Modeling often involves a sophisticated transformation of properties between original thing and model. Of course, this can have non-intended, non-trivial consequences, beyond just, e.g., looking for a line on the ground at the border of the “real” city of Athens. For example, in

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sical Studies. For computer simulations of this epistemological model, see Pauwels and Bod (2013).

42 The same problem exists in several other fields of study and in particular in many areas of science: for example, an "experiment" is as impossible in astrophysics as it is in historical studies.

43 See Ciula and Marras (2016) on the pragmatic dimension of modeling in the digital humanities.

44 Of course, this does not exclude the possibility that the single sentences contain information that points beyond the sentences themselves and could be fruitfully analyzed by sophisticated methods to yield insights into relevant properties of the whole text; cf., e.g., van Cranenburgh and Bod (2017). The integrative combination of the tools and methods of current digital humanities research with the traditional hermeneutical toolbox might be the future goal of the development of the humanities at large; Bod (2013b) aptly calls this "Humanities 3.0."

treebanks there is no way to adequately represent syntactical ambiguities; instead, one has to make a clear-cut decision as to which syntactical function each element in a sentence has. This approach, however, fails at places where the ambiguity is an integral part of the meaning of the sentences, such as in those jokes or riddles whose very being a joke or a riddle essentially depends on the *actual* ambiguity of their syntactical structure.

(3) Using something as a model requires that one choose properties of the original that are to be represented by the model. How then does one choose these properties? In principle, this choice is arbitrary and subjective. As per the general definition of sign, it always depends upon that person (or entity) for whom (or which) something serves as a model. For example, someone may choose to regard a freehand drawing of some lines as a map of ancient Greece, even if no one else agreed; or one person might prefer to have the map represent political borders while another one might prefer to have it represent roadways. However, as arbitrary and subjective as this choice in principle is, it is always guided by, and takes place within, a theoretical framework, most broadly construed.

According to this framework, first, those attributes are selected that the model is thought to possess ("model attributes"); second, those attributes are selected that the model as a sign is thought to exhibit as the representation of its original ("syntactical attributes"); and, finally, a specific mapping relation is established that maps these two sets of attributes onto each other. This mapping relation (implicitly or explicitly) defines what the iconic similarity actually is that is thought to exist between the model and the original. Accordingly, the iconic similarity between the model and its object is only postulated by using something as a model, and, in effect, the judgment on how exactly the model and its object are similar is arbitrary and subjective, too, and does not depend on any "objective" similarity between them.

The theoretical framework within which the modeling process takes place need not be a full-fledged "theory," e.g., a sophisticated linguistic theory in the case of treebank analyses. Rather, any "theoretical" perspective, most broadly construed, can serve as a framework, even if only the (set of) notions provided by the natural language. As a rule, there is no necessity to choose any one *specific* theoretical framework; for example, we may decide to draw a map in accordance with what the natural language implies are features of a "map," or we can decide to draw a map according to strictly technical cartographic standards. Either map, however, will be a "map" and as such a model; and in any case, what each specific "map" means and what its semantic content is will be determined by the theoretical framework within which the mapping relation is established.

The choice of the theoretical framework all but determines the results we can achieve by using a specific model. For example, in treebanks we can use different grammatical frameworks for describing the syntactical dependencies in a sentence and each choice provides us with a different set of options for classification.[45] In effect, the explicit and implicit theoretical frameworks we have to use in modeling not only enable the building and use of models, but at the same time also determine their meaning and heuristic value. An important consequence in the digital humanities is that the basic setup of computers and the theoretical presuppositions of computer science become (implicit or explicit) presuppositions of digital models, too. For example, since we do not use analog computers and no infinite-precision real numbers can be used, in computer simulations of physical processes the parameter of time is in effect conceived of as being not continuous, but discrete, with all the obvious ramifications as to the precision and validity of the results, especially in non-linear contexts.

(4) Though models always have a theoretical framework, they are neither "theories" nor "descriptions," even if, of course, theories can imply and descriptions can describe (and thus effectively establish) models.[46] This is implied by the fundamental definition of models as icons, which rules out that they are truth-apt signs, since icons are (so-called) "rhemes" which are in principle non-truth-apt. Theories, on the other hand, are to be classified as complex truth-apt "symbolic" signs, namely (so-called) "arguments" or at least "dicisigns."[47]

It directly follows that what models stand for, and therefore a part of their "meaning," is not determined by the constitution of the thing acting as the model itself, because the relation between sign and object is by definition nei-

[45] To give an instructive example from Classical Studies, the "Ancient Greek Dependency Treebank" (<https://perseusdl.github.io/treebank_data/>) uses an annotation scheme that is based on Smyth (1956); see Celano (2016). However, this grammar is, with regard to the syntactical phenomena that are covered, less suitable from a scholarly perspective than, e.g., both Kühner and Gerth (1898-1904) whose classificatory scheme is arguably more detailed, complete, and adequate (cf., e.g., the description of conditional sentences) and Schwyzer (1988/1990) who describes the phenomena from a linguistically more up-to-date perspective. Even if, as Celano (2016) holds, the syntactical categories provided by Smyth's grammar (1956) might be relatively easy to implement, it is evident that the choice of this grammar will not in a few cases lead to non-trivial differences in the results of the syntactical analyses, with obvious consequences for the outcome of any further statistical analyses.

[46] For the latter, an instructive example is Euclid's *Elements,* one of the first and for the history of science most important and influential exemplars of systematic mathematical modeling; see Lattmann (2018); cf. Asper (2007) on the general characteristic of this treatise and its cultural-historical context at large.

[47] The details of the threefold classification of all signs into rhemes, dicisigns, and arguments are not relevant here; see Peirce CP 2.250-253. This classification is independent of, and orthogonal to, the one into icons, indices, and symbols, for it does not relate to the relation between sign and object, but to the relation between sign and interpretant: see Peirce CP 2.243. On propositions ("dicisigns"/"dicent signs") see Peirce CP 2.309-388 and Stjernfelt (2015). An icon is by definition a rheme (see Peirce CP 2.250 and 2.255) and in particular not a dicisign (see Peirce CP 2.314). An obvious implication of the fact that theories are arguments (or dicisigns) is that theories are (composite and complex) semiotic representations and therefore signs, too.

ther independently fixed by an actually existing relation between these two things nor habitualized as in the case of "indices" and "symbols," respectively.[48] Technically, the object of the model is what the object of the model *could* be, for models are signs of potentiality.[49] In consequence, all our interpretations (and "uses") of models, insofar as they are applied to anything beyond the model itself (its object etc.), are not pre-determined by the model itself; transparent examples are obscure metaphors. However, the theoretical framework of a model often acts as a counteracting force that guides our interpretations of the model. For example, whereas the natural language in most cases allows a large number of different and competing interpretations of a mathematical diagram, our theoretical understanding of mathematical diagrams suggests a more or less rigid and technical interpretation of any mathematical diagram, at least with regard to those aspects that are deemed relevant from the viewpoint of mathematics. Nonetheless, this lack of interpretative freedom is probably a sign of rather mature theories, whereas especially in new fields of research we might expect to witness a heuristic use of models that, by applying the general method of acquiring knowledge as described above, successively reduces the vast number of possible interpretations of the models in question. Especially in such a context, the use of models can be regarded as a substitute for experimentation, especially in the (digital) humanities.[50]

(5) This finally leads to recognizing what, arguably, the greatest benefit of modeling is. Even if models cannot exhibit any reason for why they might be adequate or not, what they *can* do is, as some form of embodied knowledge that can be directly inspected and investigated, mediate between theory and "real" thing, and this by iconically displaying and showing those properties of the original thing that would otherwise not be perceivable at all, even if only in

[48] It is worth stressing that models in principle have a "meaning." As Ciula and Marras (2016) remark, it directly follows that models are not only tools, but also genuine objects of study for the humanities. This also relates to the models that are used in scientific research.

[49] Cf. Peirce CP 2.247: "An *Icon* is a sign which refers to the Object that it denotes merely by virtue of characters of its own, and which it possesses, just the same, whether any such Object actually exists or not." On the connection between the notions of monadic quality and potentiality see Peirce CP 1.422-426. Describing models as signs of potentiality is preferable to regarding them as something similar to (literary) fiction: see, e.g., Frigg (2010a, 2010b). In effect, this invalidates the criticism raised against the similarity view of models; cf. Frigg and Nguyen (2017, ch. 4). Another point worth noting is that Peirce's definition of icon implies that the widespread use of the term "ontology" in computer science in the context of modeling is misleading, all the more so as it ignores the fact that any model relation is dependent on the pragmatic use of something as a model, with the consequence that any similarity between model and object depends on the judgment of the model user; cf. Ciula and Marras (2016).

[50] Cf. Stjernfelt (2011), especially on the usefulness of diagrams for experimentation. This is one of the reasons why Peirce developed the theory of "existential graphs"; cf. Peirce MS 514 (1909) and, recently, Sowa (2000) who took up that theory for a comprehensive theory of knowledge representation from a contemporary perspective.

the mode of potentiality and in the framework of a theory that guides our explications of the model. Given this, models can count as the most basic, if not only, source of genuine creativity. This is made clear by Peirce himself when he states the following regarding the usefulness of icons (and thus models) in general: "[A] great distinguishing property of the icon is that by the direct observation of it other truths concerning its object can be discovered than those which suffice to determine its construction. […] Given a conventional or other general sign of an object, to deduce any other truth than that which it explicitly signifies, it is necessary, in all cases, to replace that sign by an icon" (Peirce CP 2.279).[51] Though simple or complex "symbols," such as definitions, propositions, descriptions and theories, can represent and convey analytic knowledge and "truth" proper, only models can lead to *genuinely* novel insights. Models, therefore, form the fundamental and indispensable basis for progress in scientific as well as in digital humanities research.

4. Discussion

Gunnar Olsson's Questions

Gunnar Olsson addressed the importance of translation for being a human. He describes the human being as a genuinely semiotic animal whose life consists of translating signs between the areas of the arts, science, and religion. To each of these areas, he assigns one of the three fundamental types of sign according to Charles S. Peirce, namely icons to the arts, indices to science, and symbols to religion. In so doing, Gunnar Olsson locates the activity of translation at the core of the human condition, for we are doing nothing but constantly exchanging signs for other signs in a never-ending interplay of identity and difference.

My answers

I find Gunnar Olsson's perspective engaging and stimulating, especially from the viewpoint of model theory. If we understand models as icons on the lines of my position statement, it is just and only modeling, conceived of as thinking in the mode of iconicity, that provides us with, and actually *is*, the very source of the contents of human thought. Models are the first starting-points of each and every enquiry, and they are genuinely situated in the realm of creativity, that is the arts, most broadly construed. As such, these iconic signs are subsequently transformed by the activity of "translation," not only into other models, but also into scientific "knowledge" and/or religious "belief." But, as Gunnar Olsson's position implies, the relevance of modeling does not stop there. The secondary indexical and symbolic signs do not serve as the final products of the semiotic

[51] See Ciula and Eide (2017) on the creative aspects involved in modeling in the digital humanities.

activity of human beings, but they can be, and actually *are*, used to create new signs in turn, in particular in the mode of iconicity. These new models provide us with further, ideally more advanced, starting-points of scientific and/or religious enquiry. In effect, models not only are the ultimate source of human thought and creativity, but, insofar as we cannot escape our being humans and thus living beings in space and time, they are, in principle, also informed and shaped by our previous states of mind; that is, in short, by who and what we are. Modeling, therefore, turns out to be an integral as well as indispensable part of what it means to be a human being indeed.

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Modelling Practices and Practices of Modelling

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Abstract: *»Modellierungspraktiken und Praktiken der Modellierung«*. Modelling represents a core method of investigation in the sciences. Relying on a number of case studies, I want to explore the main concepts that denote the practice of modeling in pure and applied sciences. I argue that these concepts could be seen as metaphors to reflect upon when exploring how the practices of modeling are characterised across different disciplines.

Keywords: Mathematical models, numerical models, computational science, scientific discovery, data-science.

1. Introduction

Modelling is pervasive in the sciences, where it represents a core method of investigation as well as a subject of research *per se*. This paper considers some concepts that characterise the practice of modeling in pure and applied science. I argue that these concepts could be useful metaphors in trying to understand how models are used to investigate or represent reality.

2. Topics in Modelling

There are many examples of how mathematical models are exploited in science and engineering. Effectively, J. T. Oden points out that mathematical models "provide the vehicle with which precision is given to theory and to the mental processes used to establish and perpetuate what is known in science and engineering" (Oden 2002, 13).

Use cases include, among others, fluid dynamics and turbulence, wave propagation in complex layered media, and the prediction of the behaviour of complex engineered systems. With reference to this latter application area, in Fig. 1 some results of an integrity analysis simulation for a component of the Large Hadron Collider (LHC) at CERN in Geneva are shown. The numerical

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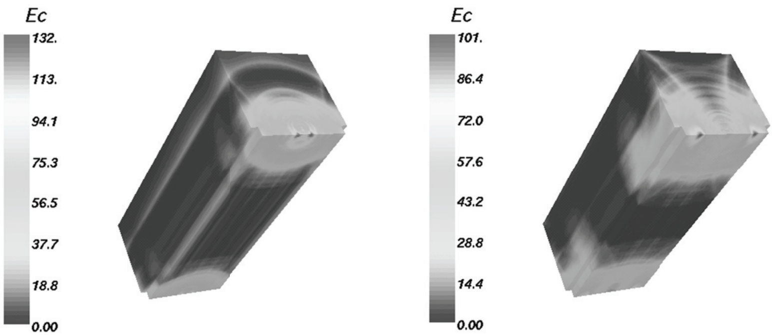
computations account for the coupled thermal and structural responses of the component to the loads due to high energy proton beam deposition. The results of numerous simulations of the baseline design (not shown here) demonstrated a possible lack of structural integrity under specific conditions in some of the components. For the sake of optimisation, the design was revised accordingly — a new material was selected that would guarantee their structural integrity where necessary, and modifications of the geometry were adopted to optimise the performance of the whole system.

From this example and from many others as well[1], it is apparent that the use of mathematical models for the simulation of complex physical phenomena as opposed to the use of experiments has nowadays emerged as a novel part of the scientific method in addition to theory and observation.

Figure 1: Computer Simulation of the Structural Thermoelastic Response of an LHC Component Subject to Extreme Loads



Computed distribution of kinetic energy at time t = 12µs (left) and t = 16µ (right). Calculation carried out at CRS4, (L. Bruno, G. Fotia, Y. Kadi, F. Maggio, L. Massidda, and F. Mura, 1998–2004).

Yet numerical (or computational) models are necessarily tied to experimental data, and this suggests that we should explore how these models are validated and in some cases improved by the use of experimental data. For example, A. Quarteroni notes that

> I am not aware of any numerical method which can produce valid and accurate results on a variety of complex problems without exploiting to a certain extent information which are provided by experimental measurements (Quarteroni 2004, 5).

[1] See Stein, de Borst, and Hughes (2017) for a comprehensive presentation of the subject and an exhaustive overview of the recent developments in this area of research.

This remark suggests that the concept of reliability of predictions is essential to the practice of computational modelling. In fact, it is generally agreed that the reliability of a computer simulation (i.e the measure of confidence that can be assigned to it)

> depends upon the assessment and control of errors inevitable in the computational process – modeling errors due to the impossibility of capturing all of nature with mathematical abstraction and approximation error due to the impossibility of solving exactly the mathematical models. (Oden 2002, 15)

Another concept that is worth further methodological investigations is the use of computing as an heuristic tool (Lax 1999, 24-8 passim). In a recent interview, P. D. Lax reports that John Von Neumann already realised in 1945 that computing, that is the practice of running a numerical model on a computer,

> [...] gives us those hints without which any progress is unattainable, what the phenomena are that we are looking for." In other words, computing may be used not only for solving concrete problems "but rather to explore which way science should be developed (Lax 2004, 3).

Not surprisingly, computational models are now well established as a tool for theoretical investigation in science, (see e.g. McCurdy et al. 2002). For example, massive computation of turbulence – performed by solving the exact equations of hydrodynamic turbulence – have provided new quantitative data and enhanced the understanding of this area (see e.g. Yeung, Zhai, and Sreenivasan 2015). This suggests to us that it is worthwhile to further investigate the concept of computing as an instrument for discovery in the sciences and to understand how computational models are used in this endeavour.

Further opportunities to reflect upon the way to describe the practice of modeling in the sciences are provided by examining how these practices are viewed from the perspective of the now emerging data-driven science.

In recent years, in fact, data driven science has emerged as a novel framework, due to recent developments in the technology of experimentation and measurement. This trend has forced scientists to change their attitudes toward data, and data methods are leading to transformative changes across the engineering, physical and biological sciences as well as the social sciences. Striking examples include, among many others, data-intensive computing systems (Mattmann 2014), genomics and systems biology (Stephens et al. 2015), medicine and health (Rotmensch 2017), urban informatics (Ota et al. 2016, Zhao et al. 2016), political and social sciences (Alvarez 2016), and social media and computer-mediated communication (Olshannikova et al. 2017, Barberá 2015).

Indeed, in most cases the term *data-driven modeling* seems to have relevance as opposed to a-posteriori validation (or optimisation) of models (Efron 2016, Hastie 2015). But this is not necessarily true. Interestingly enough, the use of such rich data sets has been recently proposed in conjunction with more traditional analysis, modeling, and computation. In fact, on one hand, numerical simulation of large complex systems can easily strain available computational resources. Similarly, experiments can generate overwhelming amounts of data. On the other hand, recent advances in data-driven methods are allowing for significant advances in the prediction and control of highly complex, often networked, systems.

This approach, known as Dynamic Data-Driven Applications Systems (DDAS), represents an emerging paradigm in computational science, in which "simulations and experiments (or field data) interact in real time to dramatically improve the fidelity of the simulation tool, its accuracy, and its reliability" (NSF 2006, 37). Homeland security, control of hazardous materials, environmental remediation, manufacturing processes, and vehicle flight control are just a few of the recent applications of this technology (Darema 2004). As recently pointed out (Kuske at al. 2017), it is expected that the combination of these approaches may provide a transformative mathematical framework for modeling the behaviour of complex systems. This interesting remark suggests that it might be useful to investigate how, and in what sense, these different modelling techniques are interconnected.

To sum up, there are a number of concepts that characterise the practice of modeling in the sciences. What emerges is a practice-based overview of what modelling in the context of different domains of applied sciences means in operational terms and a glimpse of what could be entailed if the practice of modelling is analysed from this viewpoint.

3. Conclusion

In this paper, I attempted to explore the concept of modeling in the context of different domains of applied sciences from the perspective of modeling as a practice. However, there are a number of issues that would need further analysis. For instance, it would be useful to further explore the relationship between theory and practice that emerges as a consequence of resorting to computations for discovery in the pure sciences.

Further opportunities to reflect upon the way to describe the practice of modeling in the sciences can be elicited by examining these concepts from the perspective of the emerging domain of data-driven science. To this end it would be important, for example, to compare a number of use cases across different disciplines.

Exploring how practices of modeling are characterised across disciplines seems to me a promising way to examine how, and in what sense, practices of modeling are interconnected, and whether and how the concept of modelling in the sciences can be appropriately (re)defined.

4. Discussion

Paul Fishwick' questions

Paul Fishwick was the respondent to my talk. While agreeing that computation is undoubtedly a pillar of contemporary science, Paul pointed out that models can also be seen as ways of physically encoding information using a specific technology, with associated analogies and metaphors. As such, they can be considered to be informational representations of our world. He considers that, if one wants to characterise exhaustively the practice of modeling, diagrammatic and physical representations, and mathematical notation, should be considered as well, and he asked me to comment on this issue. Another question he raised was about the potential connections between the concepts and the practices I discussed and the arts and humanities.

My answer

I consider that while information representation may be part of the effort of building a computational model, whether their role is essential or not is strongly dependent on the particular goal of the model building process and of the application problem one may want to solve. However, I do agree with Paul in considering that these representations should be taken into account if one wants to unravel how modeling is used in practice. As far as the potential connections between the concepts and the practices I discussed and the arts and humanities, we both agreed that data science can provide the appropriate framework for non-traditional research and discovery in the humanities. In this same framework, we posit that the concept of computing as an instrument for discovery in the sciences I described can be a useful metaphor to reflect upon when trying to unify the description of the practices of modeling in many different domains, both in science and in the humanities.

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A Humanities Based Approach to Formally Defining Information through Modelling

Paul A. Fishwick[*]

Abstract: *»Ein geisteswissenschaftlich begründeter Ansatz zur formalen Beschreibung von Information durch Modellierung.«*. A traditional, and reasonable, way of thinking about the digital and modelling within the context of the humanities is to begin with humanistic inquiry and then explore the world of information processing and management through digital technologies, such as virtual reality, computers, smartphones, and tablets. This chain of thought revolves around the idea that information is part of the world of computing with its technological methods and marvels. However, through traditional humanities topics such as language and sensory arts, we claim that the idea of information and information processing is part and parcel of the humanistic tradition. Seeing the world as information is a matter of interpretation, and not of technologically-motivated implementation, even though such implementation provides us with efficient tools for managing information. Written and pictorial languages are a basis for formalizing information and models, independent of technology.

Keywords: Information, flow, semantic network, finite state machine.

1. Definition of Modelling

Modelling represents the activity of designing, manipulating, and testing models. We characterize three types of models that cover wide territory: knowledge, shape, and behavior. A *model of knowledge* is characterized in natural language, and can be expressed in logic or in a diagrammatic syntax (e.g., semantic networks, concept graphs, mind maps). These model forms may be augmented with multimedia in the form of static or time-varying imagery. *A model of shape* reflects the goal of using scale to make the model target more accessible, or it reflects models that capture shape and geometry of the target. A child's toy and doll house are early-age examples of scale modelling, whereas a scene graph is an example of a geometric-based model of objects comprising a scene. *A model of behavior* is a structure that captures how objects change

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state over time. A state machine, Markov chain, Petri net, and differential equations are examples of behavior models.

The simplest sorts of models have come from the humanities. If we consider the arts as divided into language arts and sensory arts, models in the language arts are formed from natural language. For example, "I am going to get the mail" contains specific parts of speech that can be linked to the formation of dynamic models. The word "going" is a gerund and was formed by taking the verb "go" and adding an "ing," thus forming an activity. Since states within a system are captured by activities over a duration of time, "going" is a state within a state machine yet to be formulated. By parsing natural language, we can transition to ever more formally specified dynamic models. As for sensory arts, we find craft, design, and fine art. The sensory arts include all sensory modalities such as vision, sound, and touch. Visually specified states, events, and functions can be drawn or can be interpreted from a drawing.

Models can be considered to be information representations of our world – they are ways of physically encoding information using a specific technology, with associated analogies and metaphors. Consider the System Dynamics modelling framework of Jay Forrester. The flow graphs employ the analogy of flowing water that is restricted by valves, which model rates and tanks, which model capacities. System Dynamics models can be expressed using different technologies. These models can be created with purely mechanical components, hybrid mechanical-electrical components, or on the digital screen where one moves circles, rectangles, and arrows around to design the model. Therefore, the model is based on one or more analogies, and is independent of the technology used to manifest it–digital or otherwise.

2. Information Modelling within the Humanities

The humanities are a broad area encompassing the studies of human culture. Cultural artifacts that are produced consist of numerous materials that may be written or crafted. To the extent that an artifact has been produced by writing using the technology of print, this writing can be modelled in many ways. A semantic network can be drawn for a chapter in Melville's Moby Dick, for instance. The network becomes a model of the chapter. An artist might paint a scene from the novel, with the painting serving as a model of the text capturing that scene.

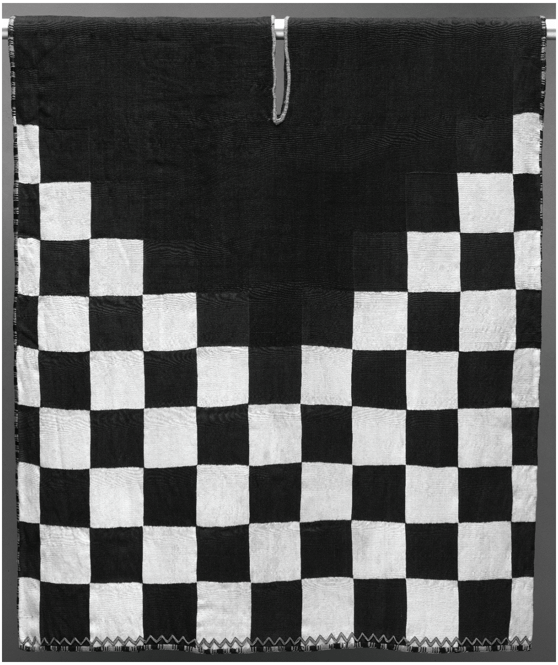
Models are viewed as artifacts that we create to understand other artifacts (Fishwick 2017). Models frequently capture the information content of the artifact. The model becomes a vehicle for framing the artifact in terms of information–seeing the artifact through an information lens. This connection between the humanities and modelling differs from the classical notion within the digital arts & humanities where the "digital" is seen as a utilitarian facet for arts and humanities. We posit that the ideas behind information are situated within the humanities and so, connecting information and the humanities is less about tools, and more about reframing our understanding about the nature of information in culture.

3. Interpreting a Cultural Artifact through an Information Lens

The following exposition is reprinted from Section 3 of Fishwick (2016) describes how we may view a 500-year old Incan tunic from the standpoint of information. In this description, the tunic becomes a catalyst for a discussion of information management and processing. The role of digital technology becomes merely an accelerant of information processing rather than a tool for traditional humanistic research. The idea of information is couched in terms of a fundamentally information-specific interpretation of the tunic, rather than as a digital tool for supporting interactive exploration.

An art museum was chosen as the venue for considering systems thinking in a Fall 2015 class in Modeling and Simulation. Students were each given a choice of an object at the Dallas Museum of Art (DMA). With some guidance, they interpreted these objects through thinking of them from a systems perspective. The guidance consisted of heuristics such as: (1) represent knowledge about the objects and their representations, resulting in a concept map; (2) consider any processes or techniques associated with the object, what is represented in the object, or in the object's material; and (3) model the object with digital or physical materials. Systems thinking is atypical in an art museum, which is why it was chosen. The goal was to illustrate variety in object interpretation that ventured beyond art history explanations. Consider the Inca tunic in Figure 1, which was highlighted within a recent exhibit (DMA-Inca 2016).

Figure 1: Tunic with Checkerboard Pattern and Stepped Yoke. Courtesy of the Dallas Museum of Art, Public Digital Media Collection.



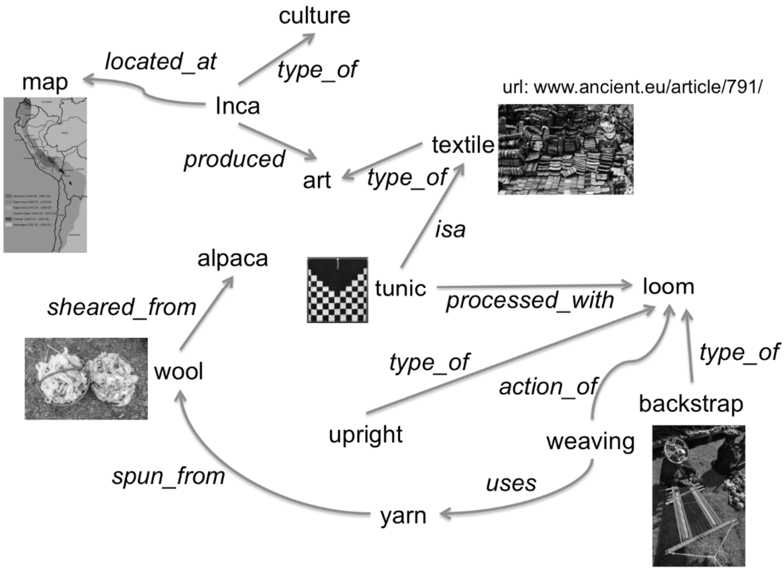
Additional Information: Inca Tunic (<https://www.dma.org/collection/artwork/pre-columbian/tunic-checkerboard-pattern-and-stepped-yoke>) (DMA-Tunic 2016).

For this tunic, there are many possible questions we may ask:

- How was the tunic originally woven?
- How would the tunic be woven today?
- Can a computer program reproduce the tunic pattern?
- How was the red fabric dyed?
- What are the population dynamics of the alpaca or llama?
- Can the colored, square motifs be used to encode information?
- What were the behaviors or rituals of the tunic wearer?
- How was the tunic exhibit installed within the museum?
- What workflow process can be used to obtain a list of all tunics?
- What is the global timeline for Inca tunics across all museums?

These questions can be answered through dynamic models of the sort employed in the field of simulation. We will cover the example of dynamic models, but first approach the study of the tunic with a concept map (Novak and Gowin 1984). The concept map is a directed graph of concepts linked by relations. For example, “Inca is a *type_of* culture” and the tunic is *processed_with* a loom, with two types of loom indicated: upright and backstrap. The concept map is a type of semantic model (Sowa 1983). A concept map of the tunic is depicted in Figure 2.

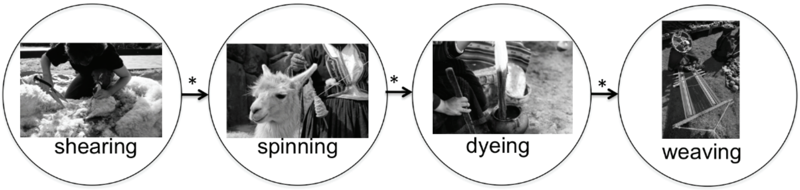
Figure 2: Concept Map of Knowledge about the Inca Tunic



Source of Images: tunic image is from the public DMA digital media collection. Map in the upper left is from Wikimedia Commons: public domain. Remaining images from Shutterstock, Inc., standard license.

The next step in seeing the tunic through the lens of systems thinking is to map out the dynamic relations. We do this by focusing on verb-based relations in English. The diagram in Figure 3 represents a finite state machine (Fishwick 1995), as it is termed in computer science (FSM 2016). Each state has a participle verb form indicating state. For example, to craft a tunic, we begin by shearing an animal from the camelid family, such as an alpaca. Thus, the system that indicates how the tunic is made can be seen as a sequence of activities (i.e., states) of different people in a sequence-based pipeline.

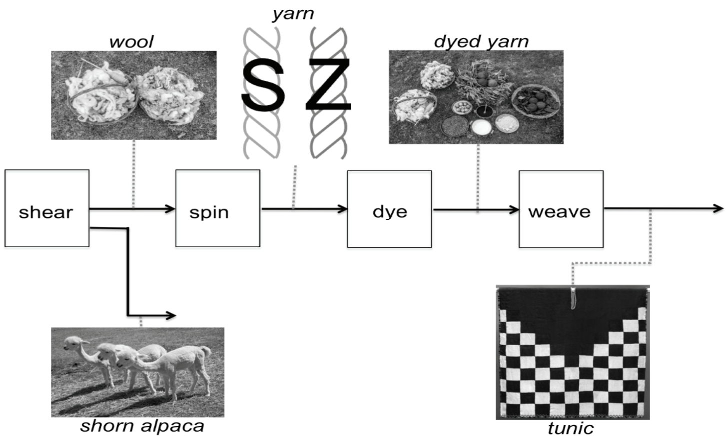
Figure 3: Four Connected States Comprising a finite State Machine (FSM) for the Tunic Process



Source of Images: Shutterstock, Inc., standard license.

Figure 4 presents the dynamics of making the tunic using a data flow graph. For data flow, information is processed from one functional node (e.g., *spin*) to the next. Starting on the left of Figure 5, an alpaca is sheared. In a more detailed model, there would be an arrow input to "shear," but this is left out for simplifying the diagram. There are two outputs from shear: one going to the wool, which subsequently must be spun, and another representing the alpaca minus the sheared wool: the shorn alpaca. Spinning can be done in one of two directions termed *S ply* versus *Z ply*.

Figure 4: A Data Flow Graph that Represents Material flowing from Left to Right. Each Node is a Function or Process, as indicated by a Verb

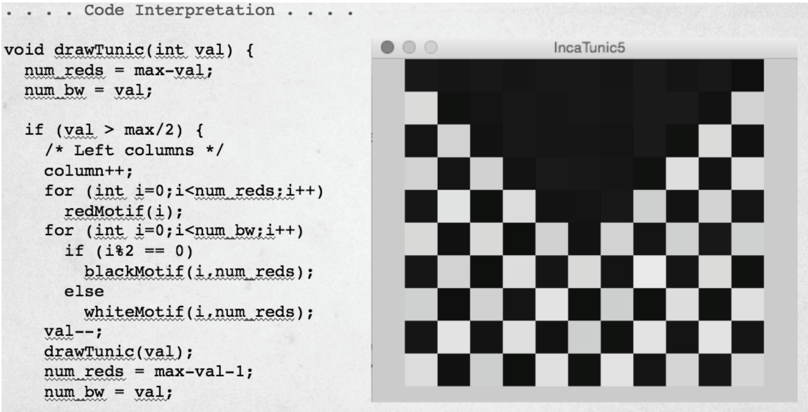


Source of Images: Shutterstock, Inc., standard license, with the exception of the S/Z image (public domain, Wikimedia Commons) and the tunic (courtesy of DMA).

Figures 2 through 4 illustrate three model types, where there is a design effort to ensure that each model component is denoted by text and some graphical cues, such as photographs. This approach to model design is deemed necessary where the visitor is belonging to a general population, rather than coming from a highly technical domain such as engineering.

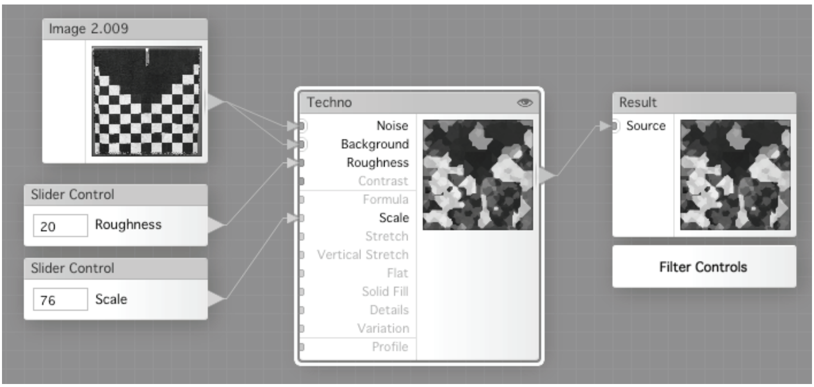
Figure 5 shows how programming can be considered modelling (of a decision procedure). A partial Processing program on the left side indicates a piece of the program, with the synthetic tunic image on the right side obtained from executing the program. The code is a textual model that captures *a computer science type of interpretation* of the original tunic.

Figure 5: A Processing Program Excerpt (left), which Produces an Image similar to the Inca Tunic (right)



Numerous other models are possible for the tunic such as the one in Figure 6 where a data flow model takes the original tunic image on the left and then applies this image, through a left-to-right flow via functional image filters.

Figure 6: A Data Flow Model that Processes Images using Filter Nodes



Program: Filterforge (<https://www.filterforge.com/>) (Filterforge 2016).

4. Discussion

I have met many colleagues with an intense interest in modelling. Examples of related research by some of these colleagues are defined by the shared concern for the possibilities of modelling, and how models compare, contrast and differ between science and engineering versus the humanities (Bod 2016; Ciula and Marras 2016; McCarty 2004). I found that, collectively speaking, we had more in common than we had differences with respect to modelling. Even though the phrase "modelling and simulation" is commonly employed in science and engineering, it was useful to separate out modelling from simulation since modelling represents a broader enterprise that cuts across all disciplines.

Giorgio Fotia was the respondent in my talk and he surfaced many interesting issues. Fotia's focus on modelling was related to modelling within the biological sciences. Most of Fotia's models were "mathematical models," meaning that the models were represented using mathematical notation. I discussed how this type of notation was one type of model notation with others coming from areas such as discrete event modelling, conceptual modelling, and modelling text. Many models are represented in diagrammatic rather than symbolic form. Figures 2 through 6 exemplify this difference.

My most important moment of learning dealt with the need for those engaged in the practice of modelling to spend more effort in dealing with model-to-model translation. Take mathematical models as an example. When a scientist uses a mathematical model, they rarely think in terms of the symbols. Instead, the symbols aggregate to correspond with laws of conservation. It is more important to see equations based on Newton's laws with natural language such as "force from ball impact" or "torque from wooden wheel." The symbols are efficient and economic, but modellers see beyond them to natural language forms, common to the language arts. Therefore, future computer interfaces that begin with natural language, or that allow these symbols to coexist with the mathematical symbols would be useful when reasoning across disciplines.

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Some Remarks on Modelling from a Computer Science Perspective

Günther Görz *

Abstract: *»Einige Bemerkungen zur Modellierung aus der Sicht der Informatik«*. One of the basic tasks of computer science is to rewrite models derived from other scientific disciplines so that they can be represented and processed on computers. If such a reconstruction process is only partially successful or fails entirely, the modification of the initial model becomes an interdisciplinary research task. The modelling task is to be seen as an application of knowledge representation and processing. We distinguish between aiming at models of something or models for some purpose. Modelling of given domains starts with the construction of a formal ontology. To support issues such as modularity and interoperability, in particular in a web-based environment, the idea of reference ontologies came up. For object-based research in the humanities, the Conceptual Reference Model (CRM) by ICOM/CIDOC is such a reference ontology which has become an ISO standard.

Keywords: Modelling, computer science, ontologies.

1. Methodological Preliminaries

My general assessment of modelling results from a general view on the humanities and the sciences, which appear in two forms: a propositional ("textbook", theory) form and a research form. The latter is a form of (methodological) action. Based on experience from interdisciplinary research, we can observe that problem orientation replaces disciplinary constrictions, which can lead to a reconstitution of the unity of science – i.e. of scientific rationality rather than systems. This unity, transcending disciplinary borders, can be seen as a unity of language, where in both cases we have similar procedures of verification and justification (*giving reasons*), which constitute meaning. That is a practical (pragmatic) unity, including the distinction between the context of discovery and the context of justification. So, it is essential for modelling to provide a linguistic framework for conceptual modelling and justification. That will

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comprise the identification of common generic concepts and relations / properties from an event, process or action perspective, respectively.

2. Computer Science and the Concept of Model

One of the basic tasks of computer science is to rewrite models derived from other scientific disciplines so that they can be represented and processed on computers. More specifically, this means that given models have to be transformed into versions for which effective procedures can be given. A key application area of reconstructed models is simulation (see Wedekind et al. 1998). If an initial model cannot be translated directly into the language of computer science, a reconstruction step is required. In the humanities in particular, understanding and explanation of actions in terms of reasons and intentionality provide challenges to operationalized representations.

If such a reconstruction process is only partially successful or fails completely, the modification of the initial model becomes an interdisciplinary research task. Key issues for success include making the disciplinary terminology more precise, modifying the modelling approach, and extending the range of computer science methods. This offers opportunities not only to refine existing knowledge, but also to develop new epistemological interests ("Erkenntnisinteressen") in the respective disciplines as well as in computer science. That is the basic meaning of *computational science* and *computational humanities*, whereby it is essential that both parties speak a common language.

When studying the creation of models and its methodological and technical foundations, the precise introduction of metalevel terms such as *model* and *simulation* becomes indispensable. In computer science we find two elaborate uses of the term *model*, one derived from mathematics and physics, the other influenced by empirical applications in natural and social sciences and in engineering.

In mathematics and theoretical computer science, the concept of *model* is used only in the context of structuring theoretic approaches. Such structural models sensu stricto exist only in logic and mathematics. The idea is often applied to physics, but there the axiom systems contain not only schematic, but also interpreted parts from the very beginning. The second understanding of *model* deriving from application areas means a certain way of describing empirical processes, mostly within a naive realistic epistemic framework. Talking about modelling some *external reality* is in fact dealing with discipline specific experimentation and observation contexts, i.e., about descriptions of relevant states of affairs. The claim that a model simplifies some part of reality does in fact refer to the simplification in such descriptions – linguistic means can only be applied to linguistic objects.

The level of detail of the initial description is determined by the research program (Lakatos) of the respective theory in which context the model is to be created. Such a research program provides the language of the description, the description standards, and the explanatory schemata. Last but not least the expectations which precede the construction of a model are formulated within this framework. Hence, modelling is an activity that has two aspects: A model must satisfy the empirical descriptions, but also the theoretical specifications. For model construction, comprehensive descriptions of states of affairs as they result from observations, etc., run through certain modifications, so called *idealizations*: values are being smoothed, different expressions of a feature are replaced by mean values, and certain influences are regarded as negligible. These modifications aim to achieve relatively simple and clear representations of empirical states of affairs as well as adaptability to pertinent theoretical structures. The result of such an idealization is called a descriptive idealized model. If it is a structural model of a theory at the same time, then the hypothetical assertive claim ("Geltungsanspruch") is regarded as confirmed and the state of affairs is seen as described, or explained, by the theory. In engineering the theoretical structure is often complemented by technical (functional) standards–this is the case of technical idealized models such as construction plans and schedules.

Simulation models are special descriptive models of technical or natural systems, which are confined to certain material restrictions. A system in general is given by a set of elements, which are bound together by certain relations and are separated by clear boundaries from its environment. A system is a technical system if its external effects as well as its internal relations are determined by objective functions ("Zielfunktionen"). The abstraction steps involved in the construction of a simulation model do not aim at the generation of a class of cases (as in the descriptive idealized model), but at the generation of a class of variations of a base case.

3. Modelling, Knowledge Representation, and Formal Ontologies

Computer science has a special role in the construction of idealized or simulation models: First, it has to organize the initial descriptions of the models in such a way that the required modelling steps can be carried out, and the descriptions and models have to be transformed into an appropriate representation. This comprises determining how objects can be represented by features or feature groups in general, which relations can be set up among them and how certain feature values are assigned meanings such that these can be processed as data; i.e. the design of data structures and processing rules.

In more detail, this means that the modelling task is to be seen as an application of knowledge representation and processing, which in my view consists of a purpose-driven formal reconstruction of a body of knowledge and its implementation in a (logical) language. Initially we can already distinguish whether our theoretical enterprise aims at *models of* something or *models for* some purpose(s). Hence, the construction of a knowledge base ("knowledge engineering") requires at least the determination and delimitation of the domain of discourse, a determination of the relevant concepts and properties ("what?" as opposed to "how?"), where properties are represented by relations ("has-"), and a hierarchical ordering of concepts and properties ("is-a"). This simple framework already allows for the representation of particular objects (individuals) as instances of concepts. Of course, in most cases there are many desirable extensions to what can be expressed such as constraints restricting properties in various ways, or the specification of properties of properties. To express further relationships between concepts and between particulars, rules ("axioms") are often introduced. Although it sounds trivial that implicit knowledge cannot be processed algorithmically, ontology construction is a good exercise to enforce the development of methods for the explicit representation of implicit knowledge. To summarize: modelling of a given domain starts with the construction of a formal ontology, which in turn can serve as the basis for the construction of a theory, often in the form of a critical reconstruction (see Görz 2016).

At this point, a short remark about semantics seems appropriate: The logical framework provides the structural part, and the meaning of content words (*concepts*) is given by a network of relations even if we include controlled vocabularies; but in an empirical setting reference must be provided by *external* grounding. Nevertheless, semantics is meant to refer to the logical framework, i.e., an inference relation. Reasoning should be performed by sound and complete inference rules as in, e.g., Description Logic. How to deal with vagueness and imprecision in such a framework is still a research question. Another challenge is to take account of conflicting information, such as diverging ascriptions of dates or places or authorship. And, of course, deductive reasoning is only one side of the coin, and must be complemented by an *ars inventoria*, i.e. heuristic procedures, as Leibniz has already stated (1679/1999).

With formal ontologies, several issues arise such as modularity and interoperability, in particular in a web-based environment. Therefore, the idea of reference ontologies, which contain generic concepts and properties relevant for many applications, came up. Specifically for object-based research in the humanities, the Conceptual Reference Model (CRM) by ICOM/CIDOC is such reference ontology, which is now an ISO standard. Its characteristic feature is that it is event-based and easily extensible: a series of extensions for geographic data, archaeology, and scientific observations have been suggested as well as many domain-specific ontologies, e.g. from the museum, library (FRBR) and archive domain, fostering the development of standardized components and libraries. Methodologically, the CRM allows for a chronotopological modelling of data. With CRM as a common reference a high level of interoperability can be achieved.

With the CRM, semi-formal representations are also possible as it allows the inclusion of (uninterpreted) text in its representations, which are in principle open for semantic disclosure at a later point in time. Our implementation in OWL-DL (Görz et al. 2008) allows us to deploy CRM-based ontologies to the Semantic Web and to publish Linked (Open) Data. Because OWL is a very expressive Description Logic, powerful reasoning engines are available. Therefore, such models can serve as explanation models, as opposed to pure functional models which result from existing popular and successful machine learning algorithms. To support cooperative research and communication, in particular for object documentation and object-based knowledge generation and processing, so-called *Virtual Research Environments* (VREs) have been developed. WissKI (Görz 2011; Scholz and Görz 2012; Scholz, Merz and Görz 2016) is such a VRE with special support for data acquisition in the mentioned event-base style through its ontology-based modelling component. Actually it has more than 20 applications in the field of cultural heritage, mostly in museum documentation, but also in providing semantic frameworks for epigraphy (Scholz et al. 2014) and the history of cartography (Görz and Scholz 2013).

To conclude with a remark on simulation: Logic-based models can serve for discrete (qualitative) simulation in a rather immediate fashion using the reasoner. From a theoretical perspective, there is an immediate connection via *proofs as programs* (Curry-Howard correspondence). The domain of continuous simulation models (System Dynamics, etc., as used in social sciences) is beyond the scope of this presentation.

4. Discussion

In the discussion with my opponent Francesca Tomasi, clarification questions have been raised which I hope to have answered by rewriting some formulations present in the text of the presentation. I had the impression that our positions are quite similar. However, I would like to take up some questions that remain. First, Francesca questioned my emphasis on justification. To me it seems clear that giving reasons is fundamental to scientific discourse from the perspective of the philosophy of science, and this includes the humanities.

The conditions and rules of argumentation may be different, but justification is essential for knowledge, as opposed to pure opinion. She then asked why understanding and explanation of actions in terms of reasons and intentions are a challenge for operationalized representations.

Besides a few clarification questions which I hope to have answered by rewriting some formulations in the text of the presentation. I had the impression that our positions are quite similar. The following questions by Francesca remain:

Francesca Tomasi's questions

1) Why do you emphasize justification?
   Answer: Giving reasons is fundamental for scientific discourse from the perspective of the philosophy of science, and this includes the humanities. The conditions and rules of argumentation may be different, but justification is essential for knowledge, as opposed to pure opinion.
2) Why is understanding and explanation of actions in terms of reasons and intentions a challenge for operationalized representations?
   Answer: The question is whether and, if so, how intention can be operationalized. Of course, this depends on our definition of intention. Although there is a highly controversial philosophical discussion about intentionality, I cannot see any viable method to formalize intention completely in line with physical terms. So we need some way to deal with it on the computational level: that's the challenge.
3) Is a model not an explanation?
   Answer: Yes, in a sense. I would prefer to say that an operational model such as a deductive or simulation model can provide explanations.
4) Do you think that the construction of the theory is next to the construction of the ontology?
   Answer: Yes, at least insofar as a formal ontology is a necessary condition for the construction of a theory in the strict – not postmodern – sense. The ontology defines the concepts, at least.

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Modelling in the Digital Humanities: Conceptual Data Models and Knowledge Organization in the Cultural Heritage Domain

Francesca Tomasi[*]

Abstract: *»Modellieren in den Digitalen Geisteswissenschaften: Konzeptuelle Datenmodelle und Wissensorganisation für das kulturelle Erbe«*. This paper explores the role of model and modelling in the field of Digital Humanities, paying special attention to the cultural heritage domain. In detail, the approach here described adopts a bi-dimensional vision: considering the model as both a process of abstraction, an interpretation from a certain point of view, and a formal language to implement this abstraction in order to create something processable by a machine. The role of conceptual models – to be converted into ontologies – as a semantic deepening of controlled vocabularies, is the translation of this vision. Ontologies are the models used in domain communities in order to share classes and predicates for conceptual interoperability. Thinking of data models as a knowledge organization system is the core of this reflection on Digital Humanities domain.

Keywords: Ontologies, knowledge, interpretation, data structures, controlled vocabularies.

1. Introduction

Model and modelling in the domain of Digital Humanities (DH) is a huge and challenging topic. It is not trivial to find a common and shareable definition, because the concept of model/modelling is related to multiple facets, integrating the humanistic point of view with the computer scientists' approach. Also, DH have their own notion of models and modelling (see in particular Orlandi 1999; Buzzetti 2002; McCarty 2004); concepts that also reflect a core method in DH in general and in my research on domain ontologies – or better on conceptual data modelling in the cultural heritage – in particular. But let us start from the beginning, from the attempt to find an appropriate definition.

We could say that the activity of modelling consists of choosing the features of the observed reality (e.g. an object in a domain) to be formally represented (the abstract model). This formalization requires the adoption of a data struc-

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ture related to a language useful for the description of the abstraction. Thus, a model refers to the declaration of the selected properties of an object, e.g. a plain text, to be translated into a machine-readable form by using a descriptive language as a representational method. Following this definition, a model is firstly a matter of extracting properties of an object as the result of an interpretation. And an interpretation is, naturally, the expression of a point of view.

In this sense, a model can never be exhaustive. Each point of view is only one of many ways to interpret the observed reality. The more viewpoints on the same object we have, the more models might be collected. So each abstraction is a possible, individual representation of an object in a domain, which is able to replicate the original object: "to an observer B, an object A* is a model of an object A to the extent that B can use A* to answer questions that interest him about A" (Minsky 1995).

But models have to be able to aggregate viewpoints. In fact, modelling also means to identify common features of a collection or extracting those patterns that could be recognized in similar resources. The similarity is a matter of sharing, i.e. sharing a genre, a type, a computational objective, a scope or a function. In this sense, modelling reveals a crowdsourced idea: sharing something within a community that decided to advocate a common idea.

By using this approach, we recognize two interrelated levels of modelling: on the one hand, the model as an abstraction, as the interpretation of the object through possibly shared and potentially multiple "lenses" (Peroni et al. 2014); on the other, the model as the choice of a language useful to implement this abstraction by creating something that is processable by a machine.

2. Controlled Vocabularies as an Abstraction

The representation of common features of the observed reality is then a matter of communicating a specific vision of the domain.

For example, a digital scholarly edition is a model because it represents the choices of the editor in creating the digital objects at each level of the representation: the transcription, the annotation or markup, the para-meta-intra-inter-textual elements, eventually the textual tradition, but also the interface, the criteria for browsing data and documents, etc. (Tomasi 2013). When the editors choose how to transcribe a document (e.g. in a diplomatic, interpretative or critical manner), or to define which features they want to be managed by the machine, they thereby define a model of the text, which they want to reproduce in a digital dimension. Each step of this process involves computational consequences.

In general, modelling, as the result of an interpretation, has to be in dialogue with a shared vision of the observed domain. This is the reason why each cultural heritage domain (from libraries to archives, from museums to galleries) endeavors to define strategies for a semantic dialogue within and between cultures that use different standard reference models.

The choice of the content model, i.e. a metadata vocabulary for describing a collection, is a matter of sharing. And sharing a model is what it takes to guarantee a basic semantic interoperability. Dublin Core (DC)[1] is, for example, a content model chosen for describing the reality through an abstraction: 15 categories able to collect all necessary features of the observed domain (a cultural heritage collection, a web page, an institutional repository, the papers of a journal, etc.).

The Text Encoding Initiative (TEI)[2] is a model expressed in embedded markup, i.e. a controlled vocabulary, a grammar or, better, a Schema (a set of elements, attributes, rules and constraints), for describing objects related to a domain, namely, the humanities. So, TEI is a common model for representing the observed reality (i.e. texts and documents in the humanities domain), but it also leaves the interpreter free to define his or her own model of the text(s)/document(s) by choosing the features to be in focus in the computational representation.

The Encoded Archival Description (EAD)[3] and the Encoded Archival Context – Corporate Bodies, Persons and Families (EAC-CPF)[4] are, again, firstly Document Type Definitions (DTDs) and Schemata created to describe archival finding aids and authority records. They are models in the archival domain, reference systems for the community. And they are both the result of the attempt to formalize the two related methodological standards, namely ISAD (International Standard for Archival Description)[5] for the archival description, and ISAAR-CPF (International Standard Archival Authority Records for Corporate Bodies, Persons and Families)[6], for the description of authority records.

Despite the different implementations, DC, EAD, EAC-CPF, and TEI are all examples among others of metadata element sets used in cultural heritage to resolve ambiguities by sharing a domain vocabulary. They want to present themselves as models, through elements and attributes, conventions, and declarations.

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1 Dublin Core Metadata Element Set, Version 1.1: <http://dublincore.org/documents/dces/> (Accessed April 20, 2017).

2 TEI P5 Guidelines, latest version 3.1.0, 2016: <http://www.tei-c.org/Guidelines/P5/> (Accessed April 20, 2017).

3 EAD: <https://www.loc.gov/ead/> (Accessed April 20, 2017).

4 EAC-CPF: <http://eac.staatsbibliothek-berlin.de/> (Accessed April 20, 2017).

5 ISAD (2nd edition), 2011: <http://www.ica.org/en/isadg-general-international-standard-archival-description-second-edition> (Accessed April 20, 2017).

6 ISAAR-CPF (2nd edition), 2011: <http://www.ica.org/en/isaar-cpf-international-standard-archival-authority-record-corporate-bodies-persons-and-families-2nd> (Accessed April 20, 2017).

Metadata models (and controlled vocabularies) take up the need to define a common conceptual architecture for a domain. It is worth noting that in the literature "metadata modelling" refers to a type of metamodelling used in software engineering and systems engineering for the analysis and construction of models applicable to and useful for some predefined class of problems. The activity of metadata modelling is reflected in a concept diagram. Unified Modeling Language (UML)[7] is the language used in the object-oriented paradigm to represent a model as a diagram. Concept, generalization, association, multiplicity and aggregation are all keywords for creating the model. So, a diagram is a model of the reality, able to represent objects in a context.

We move from controlled vocabularies to diagrams; and from diagrams to languages.

3. Languages, Data Structures and Data Types

It has indeed been said that modelling is also a matter of language. And a formal language, from a computational point of view, is a question of data structure and abstract data types, i.e. graph (the network), tree (a hierarchy), table (a relation), sequence (a list). They are, in fact, models. For all data to be organized in a digital environment one of these models is chosen to represent the observed reality. Some examples will help make this point clear:

- indeclarative markup languages, e.g. in XML, the model of the document is a tree-like structure. So the content (actually the structure) of the document is represented as a series of features hierarchically organized and nested;
- in database systems (DBMS), the more common model adopted is the relational one, namely the table. Objects are records (and thus data) and each value is related to one of the attributes (properties) that describe the reality of the objects;
- the network is the structure – the model – of the Web; but the network is also the hypertextual representation of documents (in the Web 1.0 environment), and now of interconnected data (from a Linked Open Data [LOD][8] perspective); from the sequence (a list of documents) to the graph (a network of data). Hypertext is then a model organizing data objects through their relationships.

We have to keep this aspect in mind. The formal language is another way to conceive the concept of model. The choice of the language, and of the related

7 UML: <http://www.uml.org> (Accessed April 20, 2017).

8 W3C official page on Linked Data: <http://www.w3.org/standards/semanticweb/data> (Accessed April 20, 2017).

structures, depends on the observed domain: e.g. documents (i.e. non-structured objects) or data (i.e. structured objects). With the markup, e.g. with XML as a formal meta-language, we model documents as semi-structured objects. And the aim is to reduce the narrative, in order to model content (or, better, structure) as a collection of atomic interconnected pieces to be managed as data. We move from the property-value pairs through the tree (the declarative markup language as XML) to the graph (a model as Resource Description Framework [RDF] for creating LOD).

As it has been said: in computer science, the concept of model is related to a data structure, i.e. a possible representation of a digital content or a particular way of organizing data. In this sense, the choice of the logical model (e.g. a relational database instead of a markup language) determines the computational results or, better, the computational activities and operations on the data as based on the chosen model. Hence, models play an important role in moving from theory (the abstract model) to practice, understood as the actions that can be performed (the formal language).

3.1 A Conceptual-Oriented Position

In the document community, the markup is the model, i.e. the language to represent the structure of the reality. In the data community, the model, i.e. the traditional way to represent the content of the domain, is the database. In data modelling theory, used especially in database design (although it holds true also for other contexts), we recognize three possible models, also described as three levels of abstraction of a DBMS:

- a conceptual data model
- a logical data model
- a physical data model (or better a Schema).

We begin with the latter.

At the physical level, we deal with physical means by which data are stored, which is not our level of interest.

At the logical level, we deal with structures of models again: hierarchical, network, relational and object oriented. The importance of this level lies in the fact that each chosen data structure affects the possible computational activities: even if the model is theoretical, it involves the kind of operations that we could perform with data based on one of these abstract structures (the tree, the graph, the table, the class). So the model in this case is the content, not just the structure.

Now, let us move to the first level: the conceptual data model, i.e. the abstract conceptual representation of data. On this level, data are defined from a conceptual point of view. The meaning of data depends on the context of the interrelationships with other data.

There are several notations for data modelling. The most common model is the "Entity relationship model" (E/R), because it depicts data in terms of the entities and relationships described in the data. The E/R notation yields a model, because its aim is to represent the reality as an abstraction: "this model incorporates some of the important semantic information about the real world" (Chen 1976). The conceptual model then represents concepts (entities) and connections (relationships) between them. The notation itself is an abstraction.

3.2 Ontologies and Knowledge

The same approach is adopted by ontologies, i.e. conceptual data models translated through a formal language. Again, we range between database theory and markup languages: the data-centric approach of the DBMS, the formal declarative language (XML) and the assertion (the triple) as a graph (RDF). We could say that we are dealing with the Semantic Web approach and the LOD perspective (Bizer, Heath, and Berners-Lee 2009).

In ontology design, the model is the conceptual framework. The ontology is the conceptualization of an abstraction by identifying those features, in the form of classes and predicates, which enable us to describe a domain, observed from a specific point of view. And the aim is to move from data to information in order to extract knowledge, i.e. to reveal the latent, the yet unknown. Revealing knowledge through the analysis of, for example, the context, is necessary in order to enable inferences (Daquino and Tomasi 2015). Modelling, for instance, persons, dates, places or events is an attempt to standardize a conceptual approach through relationships (Gonano et al. 2014).

EDM[9], CIDOC CRM[10] and FRBRoo[11], SKOS[12] – just to give some heterogeneous examples (see, for example, Doerr 2009) – are nothing but points of view on reality. We could assert that ontologies are the shared ideas concerning a domain, expressed with classes and properties, relationships between concepts, rules and constraints. A domain ontology is a formal, abstract representation, useful in order to semantically describe, i.e. to model, a collection of resources and to reason on data, with an inferential aim and a problem-solving approach. Another attempt to model the reality is the translation of an XML Schema, e.g. TEI, into an ontology (see, for example, Eide 2014; Ciotti and Tomasi 2015).

9 Europeana Data Model: <http://pro.europeana.eu/page/edm-documentation> (Accessed April 20, 2017).
10 CIDOC Conceptual Reference Model: <http://www.cidoc-crm.org/> (Accessed April 20, 2017).
11 FRBRoo: <http://www.cidoc-crm.org/frbroo/home-0> (Accessed April 20, 2017).
12 SKOS: <https://www.w3.org/2004/02/skos/> (Accessed April 20, 2017).

So, ontologies are models, and I think that conceptualization is the core of modelling, with reference to the issue of knowledge organization.[13] In fact, ontologies are both a way to express the semantics of a domain and a method to organize knowledge through concepts. I personally believe that in the DH domain, ontology engineering is the most effective and persuasive modelling strategy: it is a method enabling us to reproduce the brain's reasoning, i.e., the humanistic approach to interpretation.

The act of moving from controlled vocabularies to ontologies reflects the need to express the semantics that are hidden because of the absence of a content model. The creation of an interconnection through typed links is the key to solve relationships between entities in order to reveal real knowledge.

4. Final Remarks

Another definition, from the Linked Open Data perspective, is the concept of model as a conversion method:

Linked Data modelling involves data going from one model to another. For example, modelling may involve converting a tabular representation of the data to a graph-based representation. Often extracts from relational databases are modeled and converted to Linked Data to more rapidly integrate datasets from different authorities or with other open source datasets.[14]

So, the act of converting data into a different format, or using another data structure, is again a practice. The model gives the theoretical basis for a practical activity.

Finally, a model is also a question of interface. The template for a web page, for instance, is a model. The design of a page in a Content Management System (CMS) is a model. The architecture of information, understood as the position of logical components of a page, is a model. The iconic symbols are models of the reality. So, when we model a web resource, we chose a way to represent information in the visual interface: we define spaces for components and we use icons as an abstraction of an idea, we adopt glyphs as a representation of graphemes.

In conclusion, models are a guideline, models are shared by a community, models are the representation of a domain, models refer to languages and data

[13] An interesting event related to these themes is the "three-day workshop held at Brown University on data modelling in the humanities, sponsored by the NEH and the DFG, and co-organized by Fotis Jannidis and Julia Flanders". *Knowledge Organization and Data Modeling in the Humanities: An ongoing conversation*, 2012 <https://datasymposium.wordpress.com> (Accessed April 20, 2017).

[14] Best Practices for Publishing Linked Data. W3C Working Group Note 09 January 2014: <http://www.w3.org/TR/ld- bp/#MODEL> (Accessed April 20, 2017).

structures, models are a visual and iconic abstraction. Ontologies are models. Modelling is my favorite job.

5. Discussion

Günther Görz's questions (Q) and my answers (A)

Q1. I plead for a more restricted and terminological use of the term "model". As Nelson Goodman already wrote in "Languages of Art": "Few terms are used in popular and scientific discourse more promiscuously than 'model'" (171).

A1. The scope of this paper is to reflect on the concept of model by using multiple perspectives. So, yes, the term is used here in order to refer to different levels, but this is exactly what I would like to get across: the ambiguity, the multiplicity and the polysemy of the word "model".

Q2. It is true that modelling in DH is a challenging topic, but I can't see that DH already has its own notion of models and modelling compared with other interdisciplinary enterprises with computer science such as the social sciences, (cognitive) psychology, or economics.

A2. The literature in DH regarding the concept of model and modelling is so vast that I could assert that DH is elaborating its own definition.

Q3. For the formal language, the distinction between abstract data types, (concrete) data structures and their implementation should be noticed. Nevertheless, e.g. in the mentioned case of digital scholarly editions, we should distinguish between a model (the concepts, properties, constraints, structures, rules, etc.) and a particular result.

A3. In digital scholarly editing, the concept of model refers to the choice of the features to be formalized at each level of the scholarly activity. In this sense, the edition is a model: it represents the interpretative act of the editor.

Q4. I see a similar problem in calling TEI a model. In my view, TEI is first of all a formal language with an informal semantics. This view imposes several severe constraints, e.g. a fundamental tree structure due to its commitment to XML. So, I still see a deficit on the theoretical side; for me, TEI is yet more a representational framework than a model.

A4. From the formal point of view, TEI is not a model. It lacks semantics. But, from the point of view of models as a shared definition of elements and attributes related to the classification of hermeneutic aspects of a domain, TEI is a model.

Q5. Another issue is the depth of semantic modelling. In this respect, EDM, CIDOC CRM + FRBR and SKOS are not on the same level. I think we are in substantial agreement on what is said about formal ontologies: the question of semantics is tightly connected to a well-defined inference relation. Taking up TEI again, marking up named entities such as place names and representing places in a formal ontology such as CIDOC CRM are on reasonably different abstraction levels. The anything but simple question is then, how the relationship between TEI elements and CRM concepts can be formally recorded and mapped into a (partial) semantic and interoperable representation in terms of CRM, expressible in RDF/LOD. In the actually used formal systems, the most advanced of which are Descriptions logics (cf. OWL), we can deal with under specification, but not with vagueness. This is one of the very big challenges of the humanities and science.

A5. EDM, CIDOC CRM, FRBR, and SKOS are not on the same level, I agree. The semantic depth is surely different. But they are all models, i.e. point of views: how to integrate metadata vocabularies (EDM), how to use an event-centric approach in the cultural heritage (CIDOC CRM), how to document the stratification of object descriptions (FRBR), how to express structured subjects in a domain (SKOS). So, again, they are not all models from the viewpoint of formal languages to describe concepts, i.e. ontology, but because of their attempt to define a shared conceptualization. Translating the TEI Schema into an ontology (e.g. an OWL representation), or thinking on TEI as a CRM, is a challenging issue (see, for example, Eide 2014; Ciotti and Tomasi 2015).

Q6. Finally, reasoning with formal ontologies is, up to now, deductive reasoning. But for reasoning in the humanities and in science other forms are also needed, something that Leibniz called "ars inventoria".

A6. Yes, formal reasoning is the final aim. And the role of ontologies is to enable inferences through description logic formalism. But this is just one of the various ways to interpret the concept of model.

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Focus

How to Recognize a Model When You See One. Or: Claudia Schiffer and the Climate Change

Patrick Sahle *

Abstract: *»Woran erkennt man eigentlich ein Modell, wenn man einem begegnet? Oder: Claudia Schiffer und der Klimawandel«*. "Model", at first sight, is a non-academic word with a wide circulation in a variety of conversational and non-technical written discourses. In, but also beyond that it is used in different situations, in different fields, by different disciplines. It changes its meaning in these respective contexts. But how far? If there remains a common conceptual core, we would learn a lot about the essence of the notion of model as a widely shared concept. If it turns out that the usage of the word makes model a homonym with completely distinct meanings, we have to sharply distinguish who is using it in which context. To further research these questions, we need to observe where and how we encounter models in our daily and scholarly life.

Keywords: Word and meaning, phenomenology, kinds of models.

1. Intro

"Model" is a notoriously hard concept to grasp. In looking back to the workshop that took place at Wahn Manor House in February 2017 and trying to connect the interdisciplinary, yet scholarly, discussion that happened there to the even wider scope of "real life", I will open up some rather loosely connected approaches or strategies to illuminate the possibilities and restrictions of a comprehensive perspective on models and modelling.[1]

2. Model is just a Five Letter Word

Words have a birth and then they grow up. They develop and change over time. Maybe they are like families. Words as family names. Over time, they branch out. Same name, different character. They split into polysems or are just metonyms. They may be used as homonyms. Sometimes we even nickname them teapots. Some words are like twins, which can sprout in different directions. In

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[1] For the context of this contribution see Ciula et al. 2018.

the end, they can even end up as antonyms.[2] Starting from one meaning, they can build a semantic distance up to the point where they seem to lose any common ground. Words and their meanings are formed by the context they move into and they are used within. Words are innocent; they are used and abused, formed and deformed, adopted and appropriated. We use them as we like. Our pleasure is to play with them. We are justified by the understanding that we share with our communication peers: as long as they see what we mean, decode what we send, we do nothing wrong. Across our own domains meaning differs, trenches grow. The family tree, the etymological connection, is not an explanation for the current/actual/present state of a word. It does not necessarily tell us something authoritative about its meaning. Yet we can only borrow, cultivate or educe words by building upon the meaning they bring with them to the here and now. There once must have been a common ground as a starting point. There must have been a commonality that grounded their development and that might have survived that evolution, that transfer. When we use the same words in different contexts with different meanings they still refer to that common base.[3] Maybe. In a stronger or weaker way.

Model is just a five-letter word that is used in various fields of life, in science and outside of science, and in different disciplines of scholarship. It is in such wide use that it is hardly ever defined formally or precisely. Moreover, if it is defined, the scope of the consensus regarding that definition is disputable. Still, what we are looking for is the remaining common ground: the shared meaning that we can find in uses of the word "model" in the various scholarly (and non-scholarly) domains. The common sense that explains the transfer (why did they adopt *this* word?) allows for some mutual understanding and asks for the productive refinement of our own deployment of the word – in the end the deployment of models and modelling, for example in the Digital Humanities (DH) and its neighbouring fields. Maybe this can be a starting point for those interdisciplinary and inclusive/integrative metamodels the metadiscipline DH is so much interested in.

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[2] An example of a homonymic antonym from the German language is the word "billig". Originally signifying rightly, fair, reasonable, appropriate, just (like in the expression "recht und billig" – where it still persists!) it now stands for cheap, inferior, overly simple, tawdry, cheesy. One of the most obvious examples of homonyms in the English language that has developed in very different directions is "bank".

[3] Except for a coincidental homonymy without direct etymological connection. But as soon as you talk to scholars from Indo-European linguistics or other global-historical linguistics, you learn that there are no unrelated words.

3. Models in the Disciplines, Models in Situations

Real life situations, fields of discourse, and academic disciplines are operational communicative frameworks that provide for an advance in understanding. A default meaning addition. A tacit accord. A framework for reference: if you use "model" in *this* situation, I understand (or at least assume) that you mean *this* kind of model![4] Qualifiers, what linguists call determinants, are helpful in understanding the different notions and specializations of a word, but most often, they are left out of the local situation of communication. A word like "model" is used without qualifiers the more prominent, central, stable and clear its use is. Only in cross-field communication or if alternative meaning within one field exists is it necessary to specify the sense of the word.

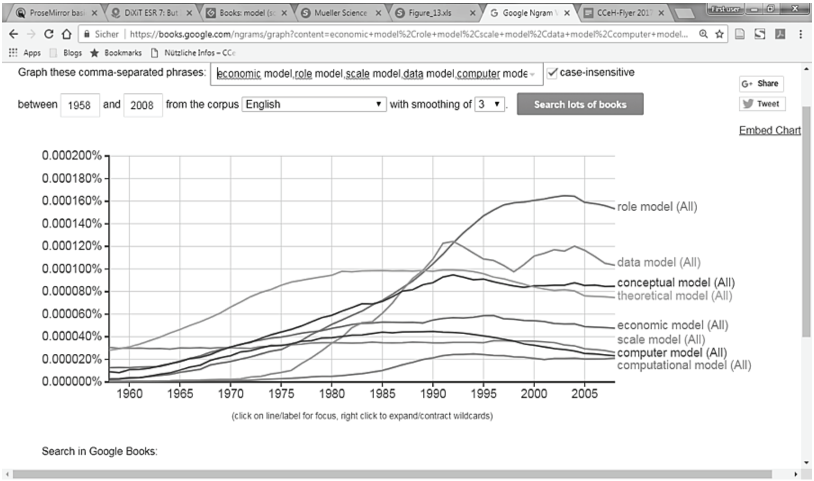
Empirical data on language usage is easier to obtain than ever. Lots of corpora are out there. The whole internet can be used as a corpus – if you take it as a source for sampling data that you maybe clean up a little bit. Tools like the Google Books n-gram viewer make use of such a corpus representing a more or less arbitrarily pooled corpus of our digitized written heritage as a mirror of our language usage. Despite all of the biases of its underlying data it suggest insights for the chronological development of the birth and growth of compound words in the domain of written books. A first harvest of compounds yields a wild collection of fruits like these: analytical model, architectural model, business model, causal model, cognitive model, computational model, computer model, conceptual model, data model, descriptive model, economic model, fashion model, formal model, graphic model, iconic model, internal model, logical model, mathematical model, mental model, object model, physical model, predictive model, process model, role model, scale model, scientific model, semantic model, social model, statistical model, structural model, transactional model, technical model, and 3D model.[5] While the use of some compounds is rather stable over time, others seem to show some trends as they gain or lose prominence.[6]

4 "Football has become more athletic in the past decades" – without further specification this would usually refer to professional men's football as the default reference. If you want to talk about youth football or women's football, you have to add the specification.

5 One of the simpler approaches is the use of the "Corpus of Contemporary American English" (COCA), see <https://corpus.byu.edu/coca>.

6 The graphic shows the Google Books Ngram Viewer results as of November 15th, 2017, data for 1958 to 2008, corpus of English, smoothing factor 3, words economic model, role model, scale model, data model, computer model, conceptual model, theoretical model, computational model. Note that in a next step of enquiry we could ask for changes in the meaning of the words by looking at their definitions or co-occurring concepts to see whether and how they become simpler, or more complex, neater, more controlled and canonized.

Figure 1: An Unreliable Impression of the Prominence of Words and Concepts



The mere collection of words do not lead to a classification or taxonomy as these words signify different ontological layers. They operationalize different perspectives. Some instances of the word model above ask for a property (an iconic model has to have a visual representation), some relate to processes or goals (like a business model). Some of them can be grouped (conceptual, theoretical), some divide a perspective (physical versus conceptual), some address domains (fashion). It should be possible to map the words or put them onto a coordinate system – maybe with abstraction and domain specificity as axes.

The question remains: Is there a common ground shared by these compounds? Where are the borderlines of meaning? Where is inclusion, where is exclusion? A fashion model is not a conceptual model. But a conceptual model can also be an iconic model. And a fashion model is an icon! Some domains are rather distinct and seem to exclude other notions. If you claim that models should only be structural or mathematical models, it follows that the use of the word model in other circumstances is plain wrong, as they are not models in this sense.[7] But as we often don't have clear definitions; notions are most often made up of a fuzzy set of meanings. There will be partial overlap between these meanings. Thus, we have to ask which of these partial meanings are comprehensive and which are exclusive? An important property of models in the sciences is the possibility of giving a formal notation to them, while other domains do not need formalization or are uninterested in pursuing it. Are we only lacking a routine of formal description for all kinds of models, taken to-

[7] "Such structural models sensu stricto exist only in logic and mathematics" - Günther Görz (2018, in this HSR Supplement), p. 164.

gether? While a narrow understanding may exclude models that have no formal notation, would it have to integrate them as soon as we have found that formal language?

There are some formal languages out there: mathematical formula, Unified Modelling Language (UML), entity-relationship models (ERM), various XML schema languages etc. But are they really universal? Or only applicable to certain domains, realizing only a certain view on modelling? How can we find the commonalities in understandings of modelling if notation systems are already too specific and exclude most cases where the term model is used? Regarding distinction and overlap, maybe we can look for:

1) The practical and theoretical use of "model" in certain domains or disciplines.
2) Interdisciplinary approaches toward the understanding of overlap between them
3) Metamodels that integrate as many disciplinary aspects as possible (within their scope of interest).
4) Underlying common sense understandings of properties of modelling.

To understand better the proliferation of meaning as well as common roots and references, I would like to propose a phenomenological approach and an empirical experiment: where and how do we encounter models, not only in our academic, but also in our "normal life"?

4. Models in the Wild

One morning at the breakfast table I say to my son (14 years): "Boy, as you go out and spend your day, could you please watch out for models, collect them and bring them home for me?" This might be a small selection of what he would report for a typical day:

1) Reading the newspaper at the breakfast table, I saw an advertisement with a fashion model. Claudia Schiffer, acting as a model, advertising a fancy dress. A model in flesh and blood?
2) On my way to school, my friend pointed to a car passing by: "look, the brand new BMW model". An instance of a model?
3) In a mathematics lesson, I was asked to answer a word problem: "Please solve this exercise by modelling the situation with a quadratic equation," the teacher said. A model as an abstract description of a part of the world?
4) In a history lesson, we saw a diagram of feudalism as a model for the organisation of power and governance in the middle ages. We learned that vassalage is a central concept in that model – a word that I had never heard of before. A model as the supposed structure of a past society?

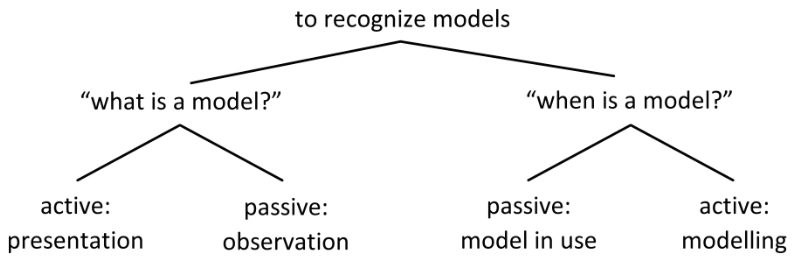
5) In a German lesson, we talked about "Wilhelm Meister's Apprenticeship", a novel by Goethe. It was said that this follows the model of the "Bildungsroman". I had the impression that what the teacher wanted to talk about was not the novel itself, but the question of literary genres. A model as a classification of types of (literary) art?
6) In a politics lesson, we had to discuss the model of "representative democracy" as we examined the German political system in comparison to others. A model as a blueprint for a political system?
7) In a geography lesson, we worked with different kinds of maps presenting models as simplified and systemised representations according to certain views of the world. A model as a visual scheme of geographical relations?
8) When I had to go to the toilet facilities during a break, I recognized the dichotomous nature of our gender model by the two icons on the doors. A model as an icon become conventional?
9) In my free time in the afternoon, I assembled a scale plastic model of a space shuttle. A model that can fit in my pocket?
10) After that, I ordered something at an online shop. I wondered what model lay behind the system that organized its data and processes. A model as information architecture?
11) At the end of the evening news, there was a weather forecast based on meteorological models. The weatherman said that the upcoming weather would be much too warm for the season but that it would match models of ongoing climate change. A model as a prediction of the future of our planet?

In all of these situations, we find models in very different senses of the word. In different "behaviours" and functions. In different relationships to the world that is modelled and to the world where objects as instances may refer back to these models. For every given case, we could discuss in which way the respective model *is* a model, *acts like* a model or *is used* as a model.

5. How to Recognize a Model

What can we learn from that? Models occur in situations; they are presented as models, recognized as models or underlie things we engage with. Models can be observed as themselves or by their effects. Models can take many forms and shapes or be of different substances. They can be made of plastic or metal, or flesh and blood. Paper that carries diagrams. Drawings, icons, symbols. Some are word based: narration or explanation, or verbal description. Some are abstract concepts: equations, formula, or formal notations. Mental models in the strict sense are even hidden in people's brains. These are models, we cannot talk about (unless we do) but could observe them by their effect (like the behaviour of these people). The relationship between world, model and instances of the model that we observe move in at least two directions: sometimes we see something as an instance or an effect of a model. Sometimes we see the model itself, representing something. In these situations, we recognize the model. In others, models present themselves more actively. Overall, we may not only ask what a model is, but also when it is. It seems there are four basic situations in which we encounter models.

Figure 2: How to Encounter Models



6. Semantic Fields

Back to language. In all situations, using the word model to describe what we have or which effects we can observe points to some semantic characteristics. Sometimes words have neighbours. Words with close meaning, synonyms, and replacements to avoid repetition. They share partial meaning and at the same time add further explanation. Exploring this neighbourhood can reveal meaning. But we have to keep an eye on the differences to get a sharper image. We may ask which words fulfil these sentences: "a model is a kind of …" or "a model is like … - but different".[8] This is my first collection: A model is sometimes like a definition, an explication, an explanation, an interpretation, a generalisation, an abstraction, a description, a depiction, an image, a drawing, a diagram, a visualisation, a symbolisation, an icon, a map, a (critical) representation, a reproduction, a miniature, a replica, a mock-up, a simulation, a function, a system, a tool, a draft, instructions for constructing something, a method for organizing knowledge, an experiment, an example, an ideal, a specimen, a type, a prototype, an analogy, a metaphor, a paradigm, a pattern, a structure, a theory, a concept. If we go through all of the potential pairs and ask ourselves, what is the difference between these words and "model", we should come up

[8] See McCarty (2004) and Goodman (1968, 171) for similar approaches.

with a rather precise description of what model actually means and what it doesn't.

Another helpful approach might tackle the problem from the opposite direction. Learn from the counterpart. Maybe the common core meaning lies in the distinction. Good definitions tell things apart. They explain what is "specific" about a thing. Can we tell what models definitely are not? Although models certainly are not most of the things or concepts in the world, the outcome of a first unsystematic survey was rather poor. What we can say, however, is that the model is neither the modelled object (or a part of the world) nor an instance based on the model. But this elementary difference is true for many other things.

Maybe there is no connection between Claudia Schiffer and Climate Change as they are models representing an understanding of the term and concept as it has evolved in different directions. Maybe there is a connection as they still share some basic properties, since they relate to certain domains in the world and as they explain something – even with predictive power.

7. Back to Basics

To find a common core in the understanding of the concept of "model", we have to look for commonalities. Trivialisation may be the prize we have to pay for this. But trivialisation is only the backside of the medal where extreme abstraction is the more shiny one that may enlighten our navigation through the landscape of models. Are there properties that all types of models share? That are shared in all domains and by all understandings?

As the model is not the modelled object or domain, we use models to refer to something, to talk about something else, to show, to simulate something else. A model stands for something. It is a placeholder, a proxy. Furthermore, models are a means for understanding, communication, and exchange. For testing, analysing, producing something. To this end, they have to fulfil some minimal requirements: Models must be either smaller, less detailed or more abstract than ... . They must be idealized and de-individualised.[9] They must contain entities, properties of elements and relationships between elements in a way that relates to the modelled object.

On this basis, we can see that even Claudia Schiffer and climate change are things of the same type.[10] Both are examples of models. Claudia Schiffer is (or was) a fashion model while models of climate change refer to global patterns of weather. Both stand for something else and are abstractions – of other "real

[9] On the aspect of idealisation see for example Morgan and Knuuttila (2012).
[10] For a more thoughtful approach towards clustering of models and common properties see the contribution by Lattmann (2018, in this HSR Supplement).

women" and of "weather that can be observed". Both present a scenario that is based on idealisation. Both can be seen as icons. But what about formalisation? Both kinds of models operate with measures and numbers! Maybe, in the end, the only difference is in the degree of formalisation and explicitness. Climate models are highly formalised while fashion models as real persons are obviously very explicit. On the other hand, even for Claudia Schiffer, a formal description of properties and measures can be given to explain why she was chosen to act as a model and how she relates to the modelled part of the world. We could even say that both models are similar in their predictive purpose and force: "the weather *will* be like this …" – "people *will* buy this dress …". And both predictions are purely statistical!

8. Outro

Our concerted workshop tried to assemble and contrast views on models and modelling from different perspectives within academic discourse. Although STEM and life sciences were underrepresented or not represented at all (with the exception of computer science and mathematics), the differences already seemed to dominate over the common ground. Some participants might have felt out of place. They thought the workshop would be about models in the digital humanities and that could only mean "data models" – while others were not interested in explicit formal models at all. In this seeming misunderstanding, the workshop proved useful and productive. It revealed the differences, trenches and gaps between academic disciplines that initially seemed to be positioned relatively close to each other. We could now conclude that every field has its own understanding and its own model of model and modelling. That it would be best to leave them alone in following their own agenda to reach their own respective goals. Maybe an understanding of models as icons is useless in computer science where algorithmic solutions are needed. Maybe formal mathematical models do not help literary scholars in conceptualizing close reading and interpretation. But to me, it is exactly in the differences and the apparent incommensurability of the various perspectives that good starting points to think about mutuality and to look for the common ground between disciplines can be located. If we see how diverging practices rely on common principles and how different fields have turned them into successful strategies, maybe we can develop a new and fruitful methodology for modelling across the disciplines. And this is, what Digital Humanities is about: we have to create metamodels all the time to make concepts and methods from the humanities operational by using approaches from engineering and computer science. We need to bridge the seeming gap between these worlds and to do so, we must understand their respective foundations.

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A Metaphorical Language for Modelling

Cristina Marras[*]

Abstract: *»Eine metaphorische Sprache des Modellierens.«*. The workshop "Thinking in Practice" aimed to integrate both theoretical and practical methodologies. Therefore, we organizers decided to combine free discussions with more playful moments, along with some focused confrontations. These playful moments were intended to establish each workshop participant's position with respect to modelling, as well as to grasp and stress the most salient concepts emerging during the different sessions and discussions. This was in fact a purposeful methodological choice that allowed us to correlate the use of certain metaphors as models for the discussion, and as paths and guidelines for the various focus-exercises.

Keywords: Metaphor, model, modelling, discussion, exercise.

1. Some Notes on Metaphors

The workshop "Thinking in practice" to which the contributions in this HSR Supplement go back, aimed to integrate both theoretical and practical methodologies. Therefore, we organizers decided to combine free discussions with more playful moments, along with some focused confrontations.[1] These playful moments were intended to establish each workshop participant's position with respect to modelling, as well as to grasp and stress the most salient concepts that emerged during the different sessions and discussions. This was in fact a purposeful methodological choice that allowed us to correlate the use of certain metaphors as models for the discussion, and as paths and guidelines for the various focus-exercises.

I strongly believe that metaphors, as figures of speech, have the capability to reveal the multiple aspects involved in a discussion; they express the necessity for any philosophical activity, and for any scientific discussion more generally, to find a balance between creative freedom and the precision and formality of philosophical and scientific discourse. Moreover, metaphors involve the double aspect of the philosophical constitution of discourse: *institution discoursive* (a

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[1] See for example Dal Lago and Rovatti 1993.

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mediation between “text” and context) and *instauration discoursive* (the relation between forms of expressiveness and speculative schemes) (Maingueneau 1995, Cossutta 1995). In this way, metaphors express the close relationship between ways of talking and ways of behaving in a discussion (Cattani 2001).
It is certainly restrictive to narrow the investigation of metaphor to fields like poetry or literature, just as it is restrictive to understand metaphor exclusively as a synonym for trope, or to consider tropes as a sort of violation of the maxims of cooperative communication. I hope it is no longer necessary to demonstrate, as Mary Hesse (1966) pointed out, that metaphors are not decorative literary instruments but rather essential processes of knowledge. Therefore, an essential part of their “nature” is that they function as arguments in philosophical discussions.

I consider philosophical discourse as *constitutive*; therefore, language is not only an instrument for philosophical communication.[2] In this sense metaphors are conceptual processes that contribute to structuring our world.[3] They are more than imaginative structures: they are not used just to remedy a conceptual insufficiency, but also to enrich argumentation. In no way does metaphor play a subordinate role. Following contemporary research on metaphor, I see metaphors as the result of an interaction between a word or an utterance and a context: they create new similarities, rather than only showing and expressing a similarity that already exists.[4] A simple juxtaposition between two domains or two terms is not sufficient to produce a metaphor. A metaphor is not a conversion into simile (whereby a metaphor is considered a form of comparison) or *vice versa* the simile converted into a metaphorical form. Metaphors open up to new contexts of meaning and become fruitful lenses and models with which to analyze and guide scientific discussions and the rationale underpinned (Tagliagambe 1997, 291).

Using Fauconnier and Turner’s theoretical model for analyzing metaphors in *Conceptual integration network* (1998), I begin by discussing the common

[2] "Contemporary philosophies, have not only recognised the role of language as in indispensable instrument of philosophical communication, but have understood that the choice of a linguistic form is neither purely arbitrary nor simply a carbon copy of reality. (...) The form is not separable from the content" (Perelman and Olbrechts-Tyteca 1991, 45).

[3] See the "Introduction: why metaphor matters to philosophy" in Johnson 1995, in particular p. 159: "we human are metaphorizing animals".

[4] The status of metaphors takes a fundamental shift between '500 and ‘600. Abandoning the prevalent line that saw metaphors as pure ornaments of discourse, metaphors became a full part of cognitive processes even if they were still undermined by imaginative elements: "quasi in miraculoso modo gli ti fa travedere l'un dentro l'altro... mirar molti obietti per un istraforo di prospettiva, che se gli originali medesimi successivamente ti venisser passando dinanzi agli occhi" (Tesauro 1978 [1654], 331), “as if by miraculous means it shows one thing inside the other... look at several angles from one hole of perspectival lens, as if the originals themselves would pass in front of your eyes” (translation courtesy of Arianna Ciula).

notions of “target” and “source” (Lakoff and Johnson 1980), referring to them in terms of space/domain. This type of analysis considers the entire process of generating metaphorical concepts. I will use it as a basis for looking at the dynamic integration between the “target domain” (in the case of the workshop the discussion on modelling) and “source domains” (aquatic and terrestrial metaphors) by *crossing* their properties. The metaphorical process is in fact multi-directional in that it involves cognitive, conceptual and cultural levels. From the interaction and intersection of different properties and dynamics a new conceptual space is created: a blending space.

2. "Thinking is an Explorative Journey"

> The whole body of science can be viewed as an ocean, which is continuous, and without any interruption or partition, even though men distinguish in it parts, to which they give names for their own use. Furthermore, just as there are unknown seas, or seas which have only been navigated by a few vessels thrown there by mere chance, so too there are sciences of which we have known something only by chance and without any planning (G.W. Leibniz, *De l’usage de l’art des combinaisons*, 1690-1716).

In the spirit of the German philosopher Gottfried Wilhelm Leibniz and his idea of collaborative knowledge (as described in the above quotation), the workshop was navigating in the open sea, aiming to explore the concepts of modelling and model, their different applications, but also their limits: their disciplinary specificities as well as their common ground.

“Thinking is an explorative journey” was the metaphorical frame chosen to guide the workshop discussion. To investigate the different applications of this frame we mainly focused on the interplay of some related metaphors, in particular the ship and the island. To do so, the workshop exercises referred to aquatic, as well as to terrestrial metaphors. These conceptual metaphors are interconnected not only because they share the same semantic field and some properties, but also because they often occur when we talk about research, research investigation, and knowledge organization. In the history of thought they have become models for structuring and mapping knowledge, for the organization of disciplines, and for modelling research practices (Marras 2017, 2014, 2013; Blumenberg 1960; McCarthy 2006). They also vehiculate a particular vision and idea of knowledge organization and acquisition, namely a system in which different types of scholarship (in this context I would use the French word *savoirs*) are seen as an interconnected net rather than as hierarchical or pyramidal structures.

Nowadays, aquatic and maritime metaphors have become integral parts of the lexicon of the digital era. The most obvious examples are seen in the use of maritime metaphors connected to the web, such as surfing and navigation. The assumption behind the workshop’s approach of “thinking in practice” is that metaphors have a cognitive and a conceptual role and that they build, or can guide the building of, models of thinking and of knowledge organization. The properties of these maritime and terrestrial metaphors seem to be adequate for capturing the nature and the characteristics of engaged discussions: fluid, dynamic investigation and confrontation aimed at exploring the surface as well as plumbing the depths. The ship (exercise 1) is supposed to be well organized; navigation has to be made with everyone's contribution (from the chef to the skipper, from the simple sailor to the officers, to the mechanic, etc.); the on-board equipment is crucial and many different things are needed (food, scientific instruments, etc.).

As the workshop was interdisciplinary, the crew included people with different competences, visions, expertise, and experiences. The route for the workshop was plotted but was also adjusted during navigation to cope with all the unforeseen events and the different routes envisaged during the discussion. While sailing (workshop), the crew was invited to find an island and to think about how to populate it, what to bring in, and what to build (exercise 2).

Through the analysis of the use of these metaphors in the workshop debate, once more, not only can metaphor be conceived as a "rhetorical ornament" but, in spite and in virtue of its informal character, it can also function as a methodological and non-conventional way to structure discourse in analogical terms.

3. Exercises

Exercise 1: Ship (time 20')

Figure 1: The Workshop Ship – Day 1

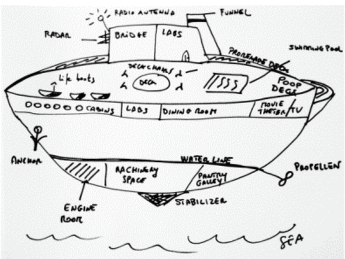
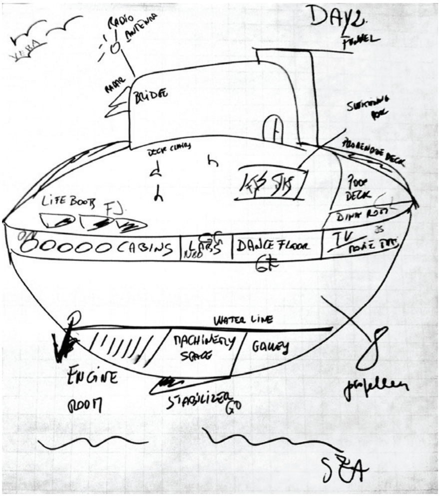


Figure 2: The Workshop Ship – Day 2



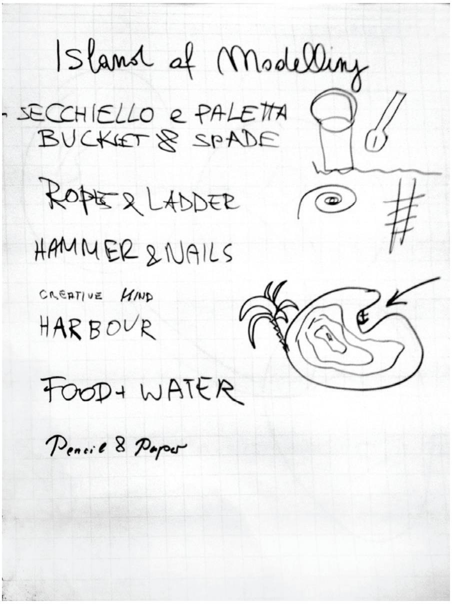
Description

A ship and its parts (detailed) were drawn on a flipchart. Each participant was asked to position him/herself in the ship according to the role he/she thinks he/she will be taking *vis a vis* the topic being discussed. Each participant was asked to briefly describe their reasons for choosing their role. The questions used to guide the exercise were related to those addressed in each participants' presented papers and to the main issues that emerged from the discussion between the pairs of paper presenters.

The "positioning phase" was followed by a brief comment or discussion once all participants had chosen their roles on the ship.

Exercise 2: The Island of Modelling (MetaMaps) (time 30')

Figure 3: Island of Modelling



Description

Somewhere in the Ocean of Knowledge there is the Island of Modelling: a destination for the ship? A place to dock the ship? The boundaries and the shape of this island had to be drawn. The island could be the ship's destination and be populated by its crew. Each participant was therefore asked to imagine the Island of Modelling, and to indicate what should be brought in and what should be built on it (infrastructures, structures, tools, etc.).

Exercise 3: Drag-and-Drop (Suitcase, Night Table, Wastebasket) (time 40')

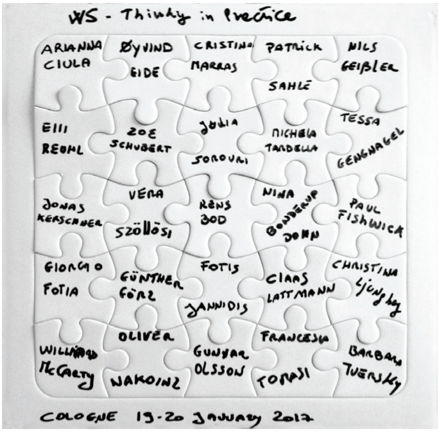
Description

At the end of the workshop each participant was asked to indicate what he/she wanted to bring with them in a suitcase for travel to and life on the Island. They were also asked what they would put on a night table to reread, review, or reflect on, and what they would like to throw away.

The exercise was intended to gather together the most salient elements, concepts, or words that emerged during the two-day workshop, to select what should further be reflected upon and investigated, as well as what was redundant or wasteful in that it did not improve our understanding of and research on modelling.

4. Conclusion

Figure 4: Puzzle



The workshop was an opportunity to experiment with different forms of languages and communication for research and science as part of its main objective to reflect on models and modelling. The conceptual metaphor, “thinking is an explorative journey”, guided the discussion and the workshop activities. The purpose was to explore different forms of meta-reflection on modelling using a participatory methodology. Different resources (reading, writing, pictures, games) were used to organize and produce shared knowledge. Participants, who came from different disciplines and research backgrounds, actively and directly contributed, individually or as groups, to the development of different perspectives and shared methodologies and definitions. We wanted to avoid the risk of bring everybody together on the “same” understanding of what modelling is. Therefore, the discussions and the common reflections and analysis stressed the importance to preserve the richness deriving for the disciplinary multiperspectivism of model and modelling.

With these exercises we in fact wanted to address a double methodological principle: transferable criteria and plural practices. Both are tentative answers to some questions the project has been investigating, namely: under which conditions and through which procedures is it possible to reproduce a model in a different context from the one in which it was originally produced? What distinctive elements should the experience of modelling (for example in a lab) have in order to meet the criteria of transferability?

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Setting the Space: Creating Surroundings for an Interdisciplinary Discourse and Sharing of (Implicit) Knowledge

Zoe Schubert & Elisabeth Reuhl *

Abstract: *»Bestimmen des Raums: Schaffen des Umfelds für einen interdisziplinären Diskurs und Austausch von (implizitem) Wissen«*. The international workshop "Thinking in Practice" was organized to explore scholarly modelling from the perspectives of researchers belonging to various disciplines. This focus on interdisciplinarity made the workshop unlike other academic meetings. Therefore it was important to build an environment and create a surrounding to share not only explicit knowledge connected to the ordinary scholarly work of the participants, but also to invite them to share their implicit knowledge, which often happens in a complex secluded network of relationships, removed from conscious knowledge sharing. Taking these aspects into account, this article reflects upon the created workshop model from an abstract view, outlining the selection of participants, location and format and how the planning contributed to a notably successful event.

Keywords: Scholarly event organization, academic meetings, workshop format, interdisciplinarity, knowledge sharing, implicit and explicit knowledge, modelling, collaboration.

1. Introduction

Exploring scholarly modelling as a formal and informal reasoning strategy across disciplinary boundaries requires gathering a diversity of concepts, methods and views. To consider modelling as the object of such an interdisciplinary investigation, and to see it as the subject matter itself, means finding ways to share appropriate knowledge and experiences from different perspectives. For this, a face-to-face meeting was needed where everything was organized in a way that allows for the transfer and sharing of knowledge and knowledge production, not only in theoretical and scientific reflection, but also in a direct confrontation of contrasting viewpoints. Experts representing different disci-

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plines have to be brought together and so the interdisciplinary workshop on modelling, *Thinking in Practice*,[1] was conceived. By including experienced scholars with their own ideas around the term and concept of modelling, the workshop aimed to collect different opinions and knowledge in order to analyze the intent and varied usages of the term modelling in and beyond the context of Digital Humanities. When bringing together experts with diverse areas of expertise, it is essential to decide on a suitable format to let them share knowledge and experiences of the subject matter gained from their particular perspectives (see Liyanage, Taha, Ballal, and Li 2009).

2. The Workshop Organization - Setting the Space

Knowledge sharing, communicating, collaborating and personal meetings belong to scholarly work and are part of most researchers' everyday lives (see Hirsch 2012, 182). Even if several of the participants of this workshop are connected to the Digital Humanities, which are inherently interdisciplinary (see Thaller 2012), each discipline involved draws on their own specific traditions and methods. To enable the sharing of thoughts across the borders of disciplines during the workshop, it was important for the scholars involved to become aware of the hidden views and assumptions which are often seen as self-evident and are rarely discussed during the ordinary scholarly work within any single discipline. In order to truly benefit from the expertise of all participants, an appropriate method had to be found for bringing to light not only explicit but also implicit knowledge collected through experience, and to make these insights accessible to others (see Nissen 2005, 13). Thus the location, participants, and format are all addressed hereafter.

2.1 The Location – Finding Suitable Surroundings

Concerning the aim of breaking with models and conventions of academic meetings, it was undesirable to use an ordinary, run-of-the-mill meeting room. The location should rather constitute an inspiring surrounding to create a stimulating atmosphere, facilitating continuous sharing as described above. For this reason, *Wahn Manor House*[2] became the venue of choice (image 1). This historical building has been rented by the University of Cologne for many years, and it houses its theater collection as well as large representative rooms. Because of the connection between the venue and theater – which can be said to be related to modelling in interesting ways – terms and characteristics from this area come to mind and can be helpful metaphors for thinking about the event.

1 <http://modellingdh.eu>.
2 <http://www.schloss-wahn.com>.

For the workshop we utilized one state room, called Gartensaal (garden hall), to function as stage and auditorium (image 2), while another smaller room, called Chinesisches Zimmer (Chinese room), was used for breaks. Both of them feature luxuriant eighteenth century oil paintings covering their walls, which establish a welcoming and inspiring contrast to the educational surroundings created to minimize distractions for students that are often found in university contexts.

Image 1: Entrance and Front Yard of Wahn Manor House

Image 2: The Workshop Room (Gartensaal)

2.2 The Participants – Bringing together Interdisciplinary Experts

Besides choosing a venue, the search for potential participants is obviously a fundamental step in making the workshop a successful event. According to the intention of the workshop, experts from various disciplines were invited, forming a network of competences around the subject of modelling in and adjacent to Digital Humanities. As this topic has not often been approached from such an interdisciplinary angle before it promised a unique opportunity to create new and unpredictable insights, and it was thus possible to secure primary researchers for the workshop. Furthermore, the workshop also presented the chance to make use of modelling as a way to reflect on the participants' own scholarly work and methods.

The resulting list of participants for the workshop was not only interdisciplinary but also diverse from the view of nationality, age, and experiences. The participants consisted of the invited speakers (both active and retired professors), guests (selected PhD students who were invited to listen to the talks), a representative of the organization funding the overall project, and the project team (four principal investigators, one research associate and four research assistants) – almost 25 people in total. The disciplines represented ranged from Archeology, Literary Studies, and Psychology to Computer Science. Continuing the theater metaphor, all attendees became actors, audience, and producers at the same time to share their knowledge and experiences with the whole group in creative ways. Switching roles was made possible through a workshop format that created a scope of action which encouraged participants to do so.

Image 3: The Group of Participants and Organizers

2.3 The Format – Crossing Disciplines, Switching Roles and Creating Impulses

To kick off the workshop, two of the research project's principal investigators acted out a dialogue while wearing masks to underline the theatrical character of their performance and link it to the venue (Ciula et al. 2018, this HSR Supplement). With this presentation, they created an appropriate atmosphere for the workshop and set the stage for the upcoming main acts. In the structure set for the workshop, the speakers were paired up, each person presenting their paper before switching roles and questioning the other on stage (image 5). In this way a dialogue was initiated on the basis of the areas of expertise of both of the presenters, before the discussion was opened to the audience (image 6). The revised articles published in this HSR Supplement also capture these dialogues. Interestingly, the questions from the respondents were comprised not only of those prepared in advance by studying their partnered speaker's position paper (circulated prior to the workshop), but also spontaneous questions which only occurred while engaging with the topic interactively. To document the dialogues, a method was used that takes into account examples and metaphors, and differentiates between explicit and implicit statements (see Geißler and Tardella 2018, this HSR Supplement).

Guided exercises were offered to facilitate the reflection and recording of results within the entire group between dialogue sessions (see Gengnagel 2018, this HSR Supplement). During these parts, all participants were encouraged to think and act creatively, so that they could adopt other, different roles, roles which had the power to heavily influence this part of the workshop's outcome by prompting spontaneous thoughts. The historical Gartensaal offered an inspiring backdrop, and the seats were placed in a U-shape to make the discussion among the group easy.

On the one hand, clear structures were provided by a program designed by the organizers in advance. On the other hand, spontaneity and improvisation by the actors, as well as the switching of roles, were encouraged since it seemed imperative to do so to properly illuminate the very complex topic of modelling. To stimulate the flow of implicit knowledge (see Nissen 2005, 13-4) about it, the workshop offered time and space for informal conversations in the smaller, adjacent room used for coffee breaks and lunch. Other parts of Wahn Manor House like the entrance hall and front yard were also accessible and allowed participants to clear their heads or search for alternative stimuli without moving too far away from the ongoing conversations. While lunch was served in the castle, the dinner was held in a nearby restaurant to provide a spatial separation from the workshop venue and to allow the workshop topic to be left behind if desired.

In order to not only intellectually move through many disciplines and thoughts, but also physically make use of the entirety of the workshop's location, the venue itself became the main focus of interest for an hour during a guided tour of the extensive theater collection, which is spread out over the entire building. It contains a variety of items originating from different countries and times, ranging from shadow puppets, miniature stage models, costume designs, archived newspaper articles, and posters, to requisites. This provided some references to a discipline otherwise not represented at the workshop and a more hands-on opportunity to discover links and metaphorical similarities to modelling.

Connected to the workshop's topic, a discussion arose based on the suggestion that this collection represents a very interesting case: typically, a collection of artifacts corresponds to a specific model with respect to the content and the items (where they are located, how they are stored). Similarly, academic meetings are most commonly constituted for a special group of scholars from one discipline. This collection, however, is organized quite differently – as this workshop also aimed to be. The castle offers contorted, narrow corridors and staircases in which parts of the collection are kept; even the historical attic is used for archiving documents. What can be observed in Wahn is in a way the modelling (of the collection) needing to adapt to an existing architectural model, which is originally intended to be used for another purpose (as a Manor House).

While preparing the workshop program, it became apparent that not only the theater collection but almost every museum can be linked to the topic of modelling in some way. For example, the art museum with its artists who used models – people as well as objects and events – to create paintings and sculptures; the ethnographic museum which models different cultures from all over the world in the space of different exhibition rooms, using objects and props to let the visitor experience a different culture for a short while.

Image 4: Øyvind Eide during the Introduction

Image 5: Giorgio Fotia and Paul Fishwick during their Dialogue

Image 6: Audience Discussion after one of the Dialogues

3. Conclusion

The examples that came up during the workshop illustrate the broad use of the term "model" in everyday language. Likewise, the dialogues and discussions during the more scholarly parts made it very clear that the term "modelling" has different meanings and usages in each of the disciplines represented by the participants. Ultimately, this once again serves to emphasize why initiatives such as this workshop are important to define and redefine the term "modelling" more precisely for academic use.

Furthermore, it became clear that it is worthwhile to invest some time, prior to and after the event, to reflect on the organization of the event and the significance for the outcomes of its participants, location, and format. The space has to be set in accordance with the subject matter and desired results, and it can be fruitful to search for connections between topic and surroundings. This article identified the main organizational tasks for the workshop *Thinking in Practice* for accommodating the group's interdisciplinarity and bringing to light the participants' implicit knowledge of the topic – exactly the motivation to hold such an event as part of the research project after all. Taking these challenges into account and creating the workshop's surroundings accordingly, as described in this article, contributed to make it a notably successful event.

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Observational Drawing. From Words to Diagrams

Nils Geißler & Michela Tardella [*]

Abstract: *»Beobachtungen in Bildern: Von Wörtern zu Diagrammen«*. In this paper we illustrate the observational activity we carried out during the workshop and its results. In our opinion this work is helpful to get a synopsis both of the event, as the development and communicative exchange of academic content, and the content itself. After introducing the criteria used for the design of an observation support tool, the observation grid, we present a list of words used to encircle the concept of model and the practice of modelling. This is followed by a list of metaphors employed in the processes of conceptualizing model and modelling, and of communicating research; finally, a list of explicit definitions is included. In the last paragraph we focus on an interesting experiment in visualizing the data extracted from each talk.

Keywords: Model, modelling, interdisciplinarity, observation, visualization.

1. Introduction

In this paper we present and discuss some of the results of the observational activity carried out by the authors of this article as part of the *Thinking in Practice* workshop. The "objects" to be examined were identified on the basis of some key questions formulated in the light of the aims of the project: how do the speakers present, structure and discuss the content of their talks? What do they wish to communicate? What examples do they use? What is the relevant terminology employed in order to define what a model and/or a modelling process is? What metaphors do they consider really effective when conceptualizing the content of their talks?

The observation work entailed, as a preliminary step, the design of an observation support tool, a grid, which was developed in order to keep track of individual contributions to the debate and the exchanges between the participants. In particular, it was designed to bring into focus some central aspects related both to the level of the expressed content and to the scholarly event

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itself. This event was a meeting between scholars to discuss, in an organized setting, a specific topic, to exchange views, and to engage in an open debate (cf. Schubert and Reuhl 2018, in this HSR Supplement).

To analyze the workshop from a linguistic and communicative point of view, we drew inspiration from Michael Halliday's model of communication (M. Halliday 1978), namely the modelling of the "Context of Situation", a notion adopted from Malinowski's theory.[1] Halliday's model covers three important aspects, which are strictly related to the linguistic choices applied in creating a text: the *field*, which gives an indication of what is being talked about and the actions and content to which the text refers; the *tenor*, which refers to the social relations existing between the individuals involved in a communicative situation (it also influences the strategies chosen to activate the linguistic exchange); and the *mode*, which describes the way the language is used in a speech interaction, including the medium (spoken, written, written to be spoken, etc.) as well as the rhetorical mode (exposition, persuasion, etc.).

The interplay between field, tenor and mode gives rise to the different possible options that are actualized in every concrete communicative context. This model seemed to us particularly suited to observe, register and analyze specific elements and aspects of the interactions between the workshop participants. Our interest was indeed in observing the modalities and the tools the participants chose for presenting their works, including their linguistic register, the coverbal gesture, and their use of space.

The observation grid was inspired both by Halliday's framework and by established research practices adopted in many disciplines – from Anthropology and Ethnology to Sociology, Psychology and Education – as useful means to record all content and to grasp and reconstruct the event by taking into account how and in which situations communicative acts were manifested.

[1] The factors involved in a communicative situation, and which are able to determine or influence the way in which the language, in its various aspects, is used, are multiple and complex. They have been formalized and modelled by scholars belonging to very different fields of research, from Linguistics (Ferdinand de Saussure's *Circuite de la Parole* and Jakobson's *communication functions*) to Anthropology (Bronislaw Malinowski's *context of situation*), from Psychology (Karl Bühler's *Organonmodell*) to Mathematics (Claude Elwood Shannon and Warren Weaver's *mathematical theory*) followed by the more recent cognitive approaches, such as Sperber and Wilson's *relevance theory*. These are just some of the models that emerged in the literature in the last decades. For an overall historical and theoretical view see Gensini (2012).

2. An Analytical Grid

The observation grid was designed to facilitate the observation and to record specific aspects of the event's content. The categories identified to guide the observers were: 1. Examples/Comparisons; 2. Words used to encircle model and modelling; 3. Metaphors; 4. Approach (how they think about the topic in general); 5. Argumentation ("Confident in his/her choices", Negotiation, Agreement, Disagreement); 6. Common definition of model (if there is any) or common points; and 7. Notes (free annotations).

The data collected in relation to these specific areas of the debate and to the definition of theoretical and practical frameworks on the part of the scholars involved has proven particularly useful for the development of the research trajectory that we are currently pursuing through the project *Modelling between Digital and Humanities: Thinking in Practice*. Terms variously related to model and modelling, their fields of application, their rhetorical aspects – both communicative and argumentative (Argumentation) and those functional for conceptualization (Metaphors) – and definitions constitute valuable resources for understanding how the notion of model and the process of modelling are conceived and positioned along the theory-praxis axis. Moreover, these elements allow us to reflect on the possibility of identifying a shared conceptual core for the two notions of model/modelling that is adopted in several disciplines, and hence is transdisciplinary.

With respect to the level of communicative exchange, we chose to monitor three specific aspects and to identify various options that would facilitate the observers' work: 1. Delivery (Reading, *Ad lib*., Slides, Other); 2. Linguistic register (Informal, Formal, Technical, Literary, Dated, Historical, Humorous, Archaic, Rare); and 3. Coverbal gesture/Use of space (Rich, Medium, Poor, Other).[2] All the aspects pertaining to the strategies of communication have been recorded but, due to time and space restrictions, not all have been analyzed. In what follows we focus on presenting and reflecting on the terminology and metaphors employed, and on the explicit definitions of model and modelling. Considerable space will be devoted to our experiment in visualizing the recorded material.

[2] The reason for these choices lies in the fact that, in our view, the communication strategies adopted – in a more or less conscious and planned way – constitute in themselves a first attempt to model the content of a talk. For example, the choice to use a visual aid, based on either images or writing, is highly revealing of the field of research, its methodology, the tools it employs and the theoretical systems within which the research in question is developed. This range of information is relevant to any research intended to study and understand whether a given concept and the practical and theoretical processes within which it is applied have any transdisciplinary potential. On the other hand, the investigation of the use of space and gestures help us understand the attitude adopted by the participants in their exchanges with colleagues often working in very different areas of research.

3. Words: Terms, Notions, Definitions

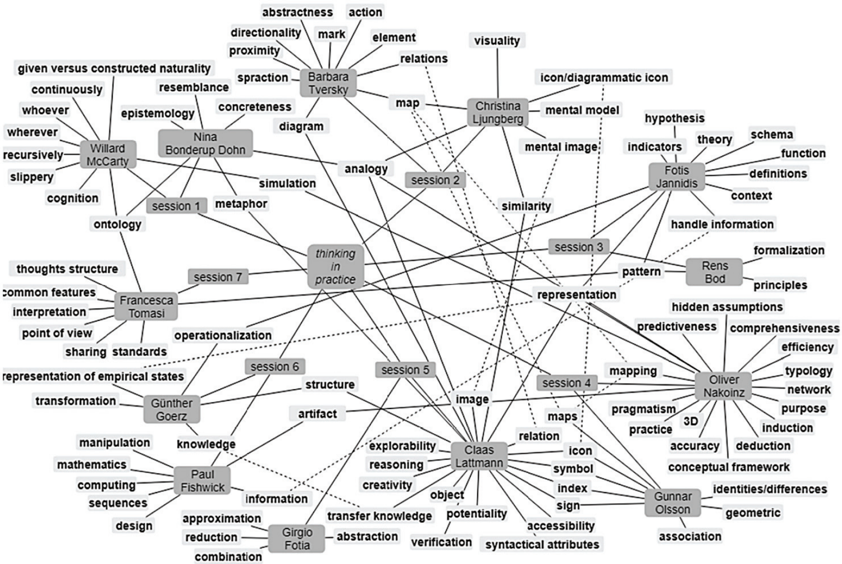
3.1 Words Used to Encircle the Concept of Model and Practice of Modelling

In this section we provide a list and a visualization of the words used by the participants to encircle the concepts of model and modelling. The terms were gathered not just from the explicit definitions provided by speakers, but also from the discourse(s) around those concepts with which the participants engaged, both in their own talks and in the discussion that followed. We attempted to represent and freeze the metalinguistic activity around these two terms, by means of which the participants delimited their meanings in their own field of research (see Figure 1).

- Willard McCarty: Ontology; Given *versus* constructed *naturality*; Cognition; Simulation; Slippery; Wherever; Whoever; Continuously; Recursively.
- Nina Bonderup Dohn: Metaphor; Resemblance; Analogy; Concreteness; Epistemology; Ontology.
- Barbara Tversky: Diagram; Mark; Schema; Action; Element; Spraction; Map; Relations; Proximity; Directionality; Abstractness.
- Christina Ljungberg: Icon/Diagrammatic Icon; Analogy; Visuality; Map; Similarity; Mental model; Mental image.
- Rens Bod: Pattern; Principles; Formalization.
- Fotis Jannidis: Pattern; Theory; Schema; Function; Hypothesis; Indicators; Context; Representation; Operationalization; Function; Handle information; Definitions ("The only true definition"); Indicators.
- Oliver Nakoinz: Network; Purpose; Practice; Simulation; Deduction; Induction; Artifact; Conceptual Framework; 3D, Simulation; Typology; Comprehensiveness; Predictiveness; Efficiency; Accuracy; Mapping; Pragmatism; Representation; Analogy; Hidden assumptions.
- Gunnar Olsson: Index; Icon; Symbol; Sign; (Communicable) Identities/Differences; Association, Geometric; Maps.
- Claas Lattmann: Sign (Index; Icon; Symbol); Similarity (Icons: Diagram, Image; Metaphor); Representation; Potentiality; Structure; Relation; Object; Transfer knowledge; Image (models); Reasoning; Creativity; Accessibility; Explorability; Verification; Analogy; Syntactical attributes.
- Giorgio Fotia: Reduction; Abstraction; Combination; Approximation.
- Paul Fishwick: Design; Manipulation; Information; Artifact; Sequences; Mathematics; Computing.
- Günther Görz: Knowledge; Representation of empirical states; Structure; Operationalization; Transformation; Simulation.

- Francesca Tomasi: Ontology; Sharing; Common features; Pattern; Thoughts structure; Standards; Interpretation; Point of view.

Figure 1: Network Diagram for the Terms Used to Encircle Model and Modelling. Dashed Lines indicate Similar or Related Terms



2.2 Metaphors Employed to Conceptualize the Contents

Far from being merely figures of speech or stylistic decorations, metaphors can be considered as fundamental cognitive schemes deeply embedded and strongly effective in human cognition and communication.[3] In this section we present the metaphors used by the participants both for vehiculating their understanding of the concepts and communicating its content in a convincing way.

1) Willard McCarty: Cosmological reconfiguration; Decolonization of thought; Machine as actor and machine's perspective; Telescope; "Computer [is like] a myriad of servants"; "Simulation [is like] let modelling go loose"; Error log, the illusion of perfect machine.

[3] Since the late nineteen-seventies significant work has been done in the field of metaphor research, both empirical and theoretical, that we cannot address here. A comprehensive overview can be found in Gibbs (2008).

2) Nina Bonderup Dohn: Models are grounded on the "Seeing as" metaphor; Metaphor of "lens" and "light"; "Learning as acquisition"[4] that means that knowledge is an object and mind is a box; "Learning as participation" that implies that knowledge is distributed, knowing is participating, the learning norms, values and ways of acting and communicating; Exploration.
3) Christina Ljungberg: Iconicity as a bridge between language and feeling.
4) Rens Bod: Metaphorical interpretation of concepts such as procedure, grammar, tree, pattern, structure, principle; "You're sitting next to them (the humanities) and try to find out what they're doing".
5) Oliver Nakoinz: Models are conceptual frameworks for handling knowledge.
6) Gunnar Olsson: *Mappa Mundi Universalis*/tetrahedron; "bouncing between the three walls"; Trajectories, points and lines and plains; "Cave wall"; Divided line; Magic trick.
7) Giorgio Fotia: Productive metaphors to describe modelling one may want to reflect upon: approximation; scale (of models); (models) heterogeneity; (model) reduction.
8) Paul Fishwick: Barometer; See an object through the information lens.
9) Günther Görz: Tree of knowledge.
10) Francesca Tomasi: multiple lens; sharing is marrying.

As it emerges from this schematic list, the most frequent metaphor employed to explain how the concept of model and the practice of modelling are conceived is the cognitive one "to know is to see". This specific metaphorical understanding also emerges from the list of words used to encircle the concept of model, among which "knowledge" and "image" are two of the most frequent terms (see § 3.1). According to this metaphor, modelling is a practice that allows us to look at (to think upon, interpret, represent) an object of knowledge, while a model is, at the same time, both an heuristic tool (lens) by means of which an object is re-described and a result of the process of redescription, a starting point for a new interpretation of the object itself.

3.3 Defining *Model* and *Modelling*

In this section we provide a synthesis of the various, more or less explicit, definitions of *model* and *modelling* proposed by the participants in the workshop. Defining something implies a theoretical effort to clarify the meanings given to a term and, simultaneously, the scholarly and/or scientific content the speaker aims to vehiculate by means of the term itself.

4 This metaphor has been taken from Sfard (1998). See Bonderup Dohn's paper (2018, in this HSR Supplement).

The goal of this exercise is not to create new definitions, but to find out if a common conceptual core can be identified and where the two concepts are positioned along the theory-practice axis.

In order to achieve these objectives, we analyze the definitions according to the approach of the "intensional definition". This kind of definition lays on the distinction between the *definiendum*, namely the concept or object to be defined; the *genus*, that is the category or the set the *definiendum* belongs to; and the *differentiae*, or the attributes that distinguish a *definiendum* from other *definienda* belonging to the same *genus.*[5]

It is worth noting that this activity is conducted on the basis of a semasiological analysis which, by taking into account the various uses of the terms, aims to circumscribe the meaning(s) given to them by scholars, in our case those involved in the workshop.

Another clarification is important: this kind of work is usually done in relation to a specific discipline, where each term is systematically described and defined in relation to other terms belonging to the same technical vocabulary and especially in relation to the terms used to define it. However, the workshop we applied our analysis to was conceived as an interdisciplinary discussion. This should imply a reflection (that we cannot undertake here) on the technical lexicons of each discipline in order to understand if, for example, the meanings given to the terms chosen as *genera* are shared among the interdisciplinary community and, consequently, to assess whether there is a theoretical framework shared among different research areas.

Building a cross-disciplinary lexicon would be a crucial step in laying the foundations of a common discourse around model and modelling. The terminological analysis shown on the following pages can be considered as a first, albeit limited, "attempt" in this direction.

1) Nina Bonderup Dohn

a) A model is "an instrument of redescription […] the model is essentially a heuristic instrument that seeks, by means of fiction, to break down an inadequate interpretation and to lay the way for a new, more adequate interpretation"[6].

b) Models are instruments for configuration and reconfiguration.

DEFINIENDUM	GENUS	DIFFERENTIA
model(s)	Instrument(s)	redescription; seeks to break down an inadequate interpretation; for configuration and reconfiguration

5 See, on this approach, A. Brahaj, M. Razum and J. Hoxha (2013).

6 This definition is borrowed from Ricoeur (1975/2003). See Bonderup Dohn's paper (2018, in this HSR Supplement).

2) Barbara Tversky

a) A model is a thinking tool.

DEFINIENDUM	GENUS	DIFFERENTIA
model	tool	thinking

3) Rens Bod

a) Formalizing or fleshing out the relation between patterns and principles is what I call modelling.

b) Modelling is a form of reasoning.

DEFINIENDUM	GENUS	DIFFERENTIA
Modelling	formalizing; fleshing out	relations between patterns and principles
Modelling	form	reasoning

4) Fotis Jannidis

a) A model is a representation of something by someone for some purpose at a specific point in time.

b) It is a representation which concentrates on some aspects – features and their relations – and disregards others.

DEFINIENDUM	GENUS	DIFFERENTIA
model	representation	of something by someone for some purpose at a specific point in time; concentrates on some aspects and disregards others

5) Oliver Nakoinz

a) A model is a simplified mapping for a special purpose[7].

DEFINIENDUM	GENUS	DIFFERENTIA
model	mapping	for special purpose

6) Claas Lattmann

a) Models are iconic signs (images, metaphors, diagrams).

b) Every model is a sign and, hence, represents something.

c) Modelling, therefore, is an act of representation. Modelling *per se* is inherently practical, that is, as being the production of a specific model.

d) Modelling is the practical particular actualization of an abstract general theory.

[7] This definition is taken from Stachowiak (1973). See Nakoinz's paper (2018, in this HSR Supplement).

DEFINIENDUM	GENUS	DIFFERENTIA
Models	sign	iconic
Modelling	act	of representation
Modelling	production	of a specific model
Modelling	actualization	of an abstract theory

7) Paul Fishwick

a) Modelling represents the activity of designing, manipulating, and testing models.

b) Models can be considered to be information representations of our world – they are ways of physically encoding information using a specific technology, with associated analogies and metaphors.

c) Models are viewed as artifacts that we create to understand other artifacts.

DEFINIENDUM	GENUS	DIFFERENTIA
Modelling	activity	of designing, manipulating, testing models
Models	representations	of our world
Models	ways	of physically encoding information
Models	artifacts	created to understand other artifacts

8) Francesca Tomasi

a) Model is, firstly, a question of extracting properties of an object as a result of an interpretation.

b) Model is also a matter of language. And a formal language, from a computational point of view, is a question of data structure and abstract data types: i.e. graph (the network), tree (a hierarchy), table (a relation), sequence (a list).

c) Model is the conceptual framework (in the field of ontology design).

d) Model as a conversion method.

e) Model is also a question of interface.

f) Models are a guideline; models are the representations of a domain.

g) Models are a visual and iconic abstraction.

h) Modelling activity is the choice of the features of the observed reality (e.g. an object in a domain) to be formally represented (the abstract model).

i) Modelling means in fact also to identify common features of a collection or extracting those patterns that could be recognized in similar resources.

DEFINIENDUM	GENUS	DIFFERENTIA
model	question	extracting properties; interface
model	matter	formal language
model	conceptual framework	
model	method	conversion
models	guidelines	
models	representations	domain
models	abstraction	iconic and visual
modelling	choice	of the features of the observed reality
modelling	identify	common features of a collection
modelling	extracting	patterns

If we group the *genera* extracted from the definitions, we see that they can be correlated with some general concepts. Concerning model(s), these concepts are: cognitive instrument (instrument, thinking tool); icon (iconic sign, iconic and visual abstraction); representation (representation, mapping); artifact; method (ways, guidelines, question, matter, conceptual framework). With respect to modelling, we can group these dynamic concepts: form (formalizing, form); action (act, production, actualization, activity); selection (choice, identifying, extracting).

This partial result confirms that the workshop's speakers link the two concepts both to practical and theoretical dimensions, with a significant remark: modelling is defined by the majority of the participants as an activity, an actualization, a production, an act; the concept is positioned on the practical side of the theory-praxis axis. In contrast "model", although conceived of as an artifact or even a concrete (visual, perceptible) representation, is mainly positioned on the side of theory, as for example as an abstraction, a framework, or a sign (although grounded in reality).[8] This distinction was kept as a common and shared conceptual framework in the discussion.

It is obvious that this preliminary analysis should be expanded, applied to a more consistent and representative *corpus* and, moreover, should also include the attributes ascribable to the *differentiae*. A tentative reflection on the latter suggest that the *differentiae* are linked to the following concepts: purpose,

[8] Nevertheless, it is worth noting that, in defining "model", two quasi-synonyms, namely "tool" and "instruments", are used in a metaphorical sense: a model in these cases is seen as a cognitive object useful to do *things* such as thinking, describing, interpreting. "Modelling" is also defined as a way of giving a form to patterns, so as a rather abstract and theoretical process.

aspect, information and feature, but a deeper and more extensive study is needed.

4. Diagrammatical Visualizations

As part of the research for the project *Modelling in Digital Humanities*, Nils Geißler charted and visualized models of text in the course of a case study concerned with visually translating definitions of modelling. It would have been an obvious approach to use established standards such as UML, ERM or OWL as a basis for this experiment, since they are well supported by software that facilitates graphical design processing or conceptual processes that can lead to automatically translated visualizations.[9] Yet we decided to manually draw diagrams to visualize the terms and their relations given by the workshop's participants to avoid possible assumptions and limitations entailed by the abovementioned standards.[10]

The aim of the study at hand is to visualize definitions (or models) of models that make them easy to compare and understand by readers without a deeper knowledge of specialized modelling languages. The goal is to provide illustrations that show the unique features and perspectives of a certain model or way of modelling and the (more) general, common features shared by other models. It also aims to draw out structures that can be found in different modelling strategies in order to emphasize what is specific to each of them.

These diagrammatical visualizations express an attempt to show the unique features of each approach towards modelling. However, this is done not in a purely textual form but by using a visual language that we hope is self-explanatory to the viewer.

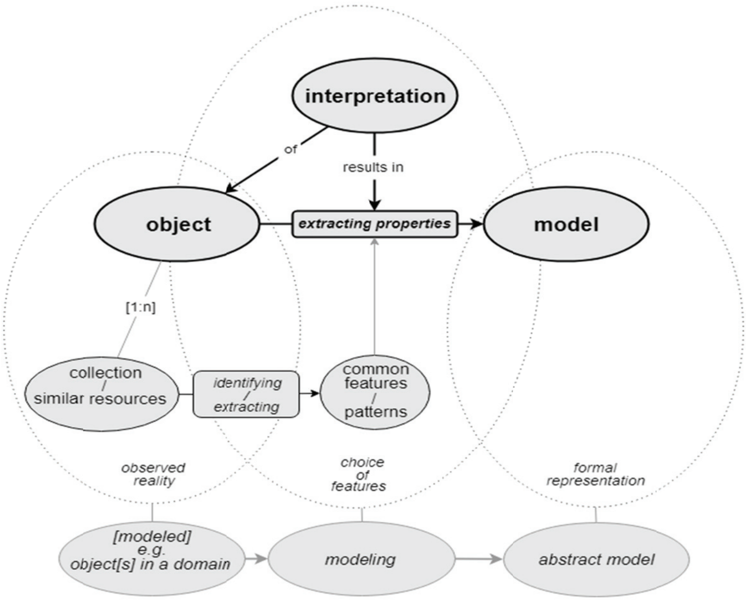
These visual expressions are accompanied and mirrored by the quotes that were originally given by the workshop participants when defining models and modelling. Thus the diagrammatical visualizations are not arbitrary, but rather connected to and grounded in textual foundations.

We picked a total of seven diagrammatical visualizations (see figure 2 to 8) to present in this article. Figure 3 and 4, and figure 5 and 6, are pairs showing alternative visualizations of the same definitions, where each alternative emphasizes a different aspect. Further explanations are given in the captions of the figures. With the exception of figure 2, all the visualizations replicate the distinction between modeller, model and modelled,[11] in order to give the reader/viewer reference points for comparison.

9 See OMG (2017), W3C (2012), and Silberschatz et al. (2011) for further reading.
10 The dangers of using standards in modelling are pointed out by Eide (2015) on page 60.
11 On this distinction see Ciula and Marras (2016) and Kralemann and Lattmann (2013).

The network diagram (figure 1) and the diagrammatical visualizations (figure 2 through 8) were created using draw.io.[12] While the latter were drawn manually, the network diagram was created semi-automatically by converting data from a JSON file into the draw.io's XML format and then manually adjusting the lines and nodes. The JSON file was initially made for a dynamic graph inspired by a blog post by Chris Pak.[13]

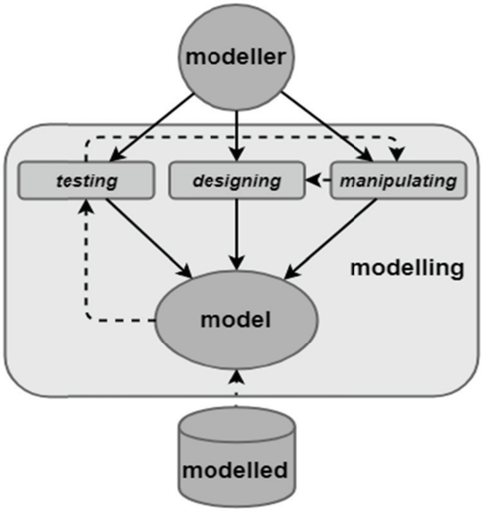
Figure 2: A Diagram Combining 8a, 8h, and 8i. Square Brackets Indicate Interpretational Additions



[12] Draw.io is a flowchart maker and online diagram software. See <https://www.draw.io>.

[13] See <http://modellingdh.uni-koeln.de/index.php/resources-2/material/blog-post-an-exercise-in-visualisation>.

Figure 3 & 4: Two Alternative Diagrams of 7a. The Second Alternative Emphasizes the Testing of the Model against the Modelled



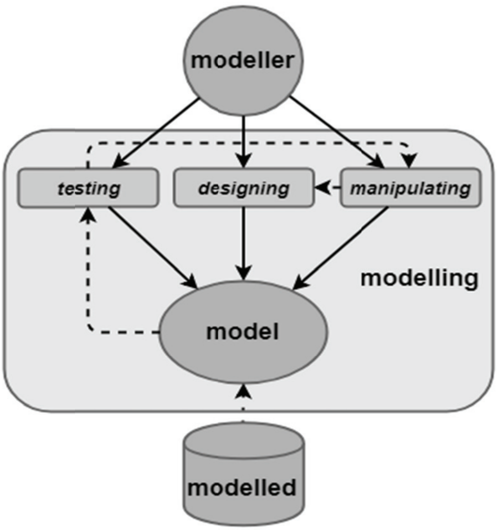
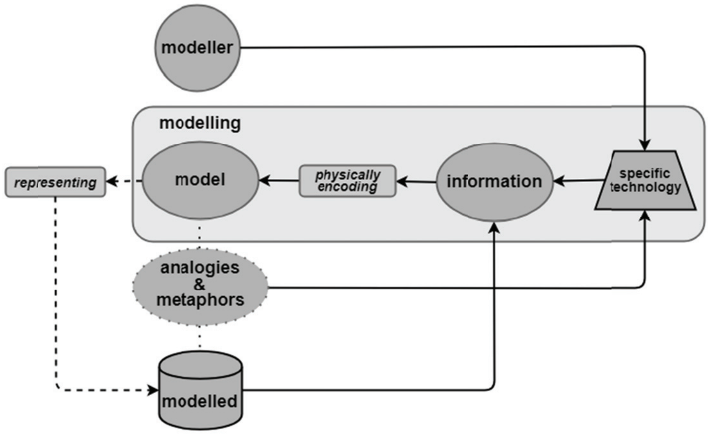


Figure 5 & 6: Two Alternative Diagrams of 7b. Both Emphasize Analogies and Metaphors as the Link between Model and Modelled, whereas the Second Alternative Gives Extra Emphasis to the Technology Used



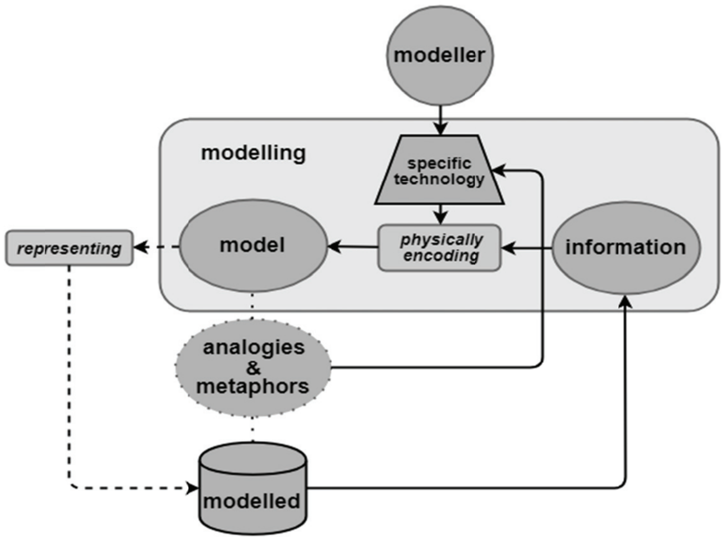


Figure 7: Diagram for 7c[14]

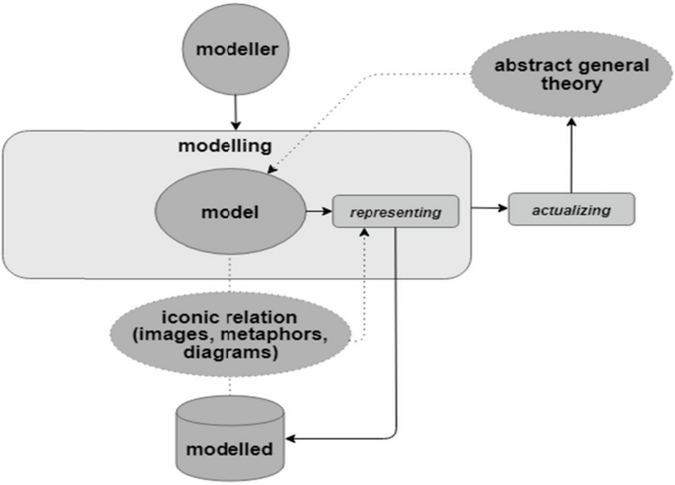
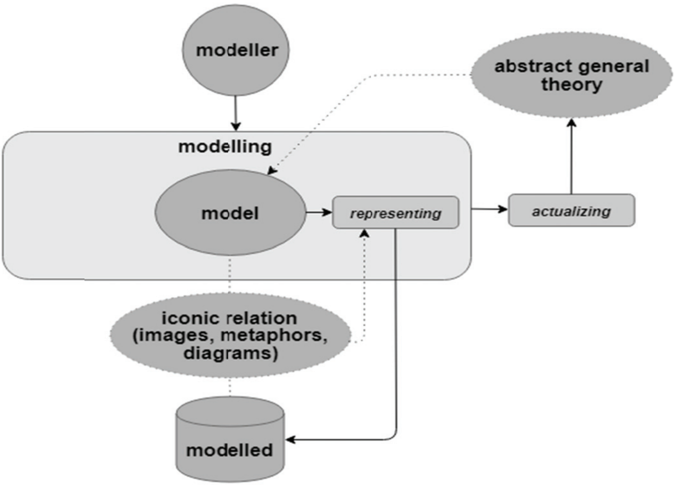


Figure 8: A combination of 6a, 6b, 6c, and 6d[15]



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14 7c. Models are viewed as artifacts that we create to understand other artifacts.

15 6a. Models are iconic signs (images, metaphors, diagrams). 6b. Every model is a sign and, hence, represents something. 6c. Modelling, therefore, is an act of representation. Modelling per se is inherently practical, that is, as being the production of a specific model. 6d. Modelling is the practical particular actualization of an abstract general theory.

5. Conclusion

In this paper we illustrated the observational activity carried out during the workshop and some of its results. In the introduction we explained the criteria used for drawing up the *observation grid*, the tool employed in order to gather the data and the information needed to develop our reflections. Then we presented a list of words used to encircle the notions of model and modelling, followed by an analysis of the metaphors adopted in the processes of conceptualizing and communicating the research presented during the workshop. Finally, a list of explicit definitions was analyzed and presented together with the visualizations of the data extracted from each talk.

The central point of this work is twofold: it enabled us to reflect on the information collected in relation to the theoretical and practical frameworks emerging from the talks at the workshop and is useful for the development of the research that we are pursuing through the project *Modelling between Digital and Humanities: Thinking in Practice*. In our opinion the terms variously related to model and modelling, the metaphors employed, and the definitions adopted or formulated by the participants constitute important resources for understanding how the notion of model and the process of modelling are conceived and positioned along the theory-praxis axis. Moreover, these elements helped us to reflect upon the possibility of identifying a shared conceptual core for the two notions that is used in several disciplines.

Working on the diagrammatical visualizations and discussing the different alternatives to drawing certain statements reconfirmed the propositions brought forward by the participants' statements. We can understand those visualizations as "[m]odels [that] are viewed as artifacts that we create to understand other artifacts" (7c), because "[m]odel is, firstly, a question of extracting properties of an object as a result of an interpretation" (8a) and "[m]odels are a visual and iconic abstraction" (8g).

Our analysis is preliminary and surely in need of enhancement, particularly with regard to the non-linguistic data. Nevertheless, the approach is valuable in itself in that it allowed us to examine the various ways in which participants from different fields of research engage in modelling, and to highlight some interesting convergences of perspectives around this concept and practice.

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The Discourse about Modelling: Some Observations from the Outside

Tessa Gengnagel[*]

Abstract: *»Einige außenperspektivische Anmerkungen zum Modellierungsdiskurs«*. This article presents some observations about the modelling discourse in the Digital Humanities from the perspective of an early stage researcher. It touches briefly on issues of interdisciplinarity and disciplinary discontinuity. Specifically, it questions the shared basis of the discourse in terms of the terminology that is used and the research literature that is commonly drawn upon. By way of example, the article calls attention to the seemingly forgotten and in any case neglected literature concerned with the conceptualization of models and modelling in science and the humanities that was produced by cyberneticists and philosophers of science in the GDR and the USSR, especially in the 1960s and 1970s. It may be argued that in order to advance the discourse about modelling in the Digital Humanities, the discourse about modelling in the humanities would have to be unearthed and considered first or at least as well, particularly where it already crossed paths with disciplines adjacent to computing.

Keywords: Interdisciplinarity, digital humanities, modelling.

1. Introduction

This article will not be about modelling. It will be about the discourse about modelling, as embodied in the workshop that spawned this HSR Supplement. I use “discourse” in a general sense of “conversation” here and not to evoke Foucault.

Since this contribution calls for an impression of my personal observation of the event, three qualifications need to be made: my interest in the topic parallels the work on my yet-to-be-finished PhD thesis, my involvement in the field as such is fairly recent – from a historical point of view – and my participation in the event was passive in nature. This will therefore amount to a short evaluation from the outside perspective of an early stage researcher.

Having said that, I want to focus on three issues:

1) Interdisciplinarity

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2) History
3) Consequences

2. Interdisciplinarity

The Digital Humanities are, *per definitionem*, an interdisciplinary field of study. This means that the practitioners draw their scholarly inspiration from varying backgrounds. One of the questions that needs to be asked, then, is how the Digital Humanities arrive at solutions that genuinely fit an inquiry *specific* to the Digital Humanities. The process required for this seems to be one of synergy and therein lies the importance of a workshop such as the one under review here.

Interdisciplinarity poses a chance and a problem. It offers a wide breadth of methodological and theoretical underpinnings while at the same time running the risk of drifting around aimlessly, with no one to take the helm. Or, as Gunnar Olsson put it in the closing discussion: "On the high seas there are no maps because there are no fix points."

This introduces an important aspect of navigational difficulty. The question is not just who guides. The question is also what to use as guidance.

I reference the metaphor of the exploring seafarer in this context because it was used during the workshop, building on Willard McCarty's introduction of the topic into the Digital Humanities discourse with his essay "Tree, Turf, Centre, Archipelago – or Wild Acre? Metaphors and Stories for Humanities Computing" (McCarty 2006). The exercises employed during the workshop first asked the participants to position themselves on an imaginary ship, then what direction their compass would be pointing, and later whether to explore an island or sail to new destinations. Thus, the approach taken to the process of synergy was one of individual introspection but, more importantly, collective sourcing.

Much is made of the collaborative nature of the Digital Humanities in contrast to the traditional humanities in which a single scholar may carry out his or her work in the proverbial quiet little chamber (from the German expression "im stillen Kämmerlein"). It might be a side effect of the practice-orientation of the Digital Humanities or one of its enabling foundations. Either way, what struck me during the workshop was that the benefits of this reality might have their limits when it comes to epistemological considerations. Ideas need to be shared in a communal space; especially in academia, where the torch continually passes from one hand to another. But there also needs to be a common ground with a common terminology. I feel like this is the stage that we are at right now: trying to ascertain a shared language *and* a shared understanding of a concept.

As Nelson Goodman wrote in his *Languages of Art*:

> Few terms are used in popular and scientific discourse more promiscuously than 'model'. A model is something to be admired or emulated, a pattern, a case in point, a type, a prototype, a specimen, a mock-up, a mathematical de-

> scription–almost anything from a naked blonde to a quadratic equation–and may bear to what it models almost any relation of symbolization. (Goodman 1976, 171)

He finds the use of the term so ubiquitous and its meaning so vague that he suggests that it should be "dispensed with [...] in favour of less ambiguous and more informative terms." (Goodman 1976, 172)

Trying to tackle the issue from a semiotic point of view might not be particularly enlightening then. In the Digital Humanities, the need for discussion arises from the computational use of the terms "model" and "modelling", as well as the narrow focus on "data modelling". Part of the *raison d'être* for the workshop and the project behind it is, I surmise, the recognition that this scope needs to be widened if there is to be progress towards a better understanding of what *scientific* models are and what they mean in the context of the humanities. This is still tied to the question of computability: in a data model, there is always a conceptual model implied and a data model can be improved when the fundamental step of *conceptually* modelling objects of study from the humanities is explicitly examined.

While there were experts from the fields of Computer Science and Mathematics present at the workshop, juxtaposed with representatives from fields such as Geography, Semiotic Literary Studies, Psychology and Archaeology, I wish that this point had been made clearer. Why are the Digital Humanities interested in modelling beyond the question of data modelling and what are they specifically interested in? Conceptual modelling would be my answer.

For this, it might have been helpful to take a closer look at conceptual models in the humanities, rather than discussing topics such as iconicity, where the debate seemed to oscillate between the visual representation of models (as in the form of graphs) – and why this is necessary for our comprehension of the world – and our visual comprehension of the world and why that is necessary to formulate models. In one of the sessions Rens Bod rightfully pointed out that examples of models from the humanities were strangely missing from many presentations, even though they exist (e.g. in the case of stemmatology).

Perhaps the question is not so much how we model but what we model. The former follows from the latter.

3. History

I will keep this point short. Still, I wanted to draw attention to the historical perspective that is often missing from the discourse. Rens Bod provided a very valuable look at the history of the humanities (Bod 2018, in this issue). One aspect that I would like to emphasize, however, is that there appears to be a wealth of epistemological writings about "models" as a concept in the Philosophy of Science that has yet to be fully unearthed. In my research, I found a number of books and articles that I deem highly relevant to the current debate in the Digital Humanities. They were written in the 1960s and 1970s by cyberneticists and philosophers in the GDR and USSR (e.g. Stachowiak 1972, 1973; Štoff 1966). I understand, of course, why they were not read or reviewed on the other side of the Iron Curtain but at least German researchers will still come across them very easily nowadays. They include attempts to classify models across science and the humanities. These classification attempts seem almost more advanced than anything under discussion today. That they were developed in the field of cybernetics which is not *en vogue* any longer but shares some significant overlap with the Digital Humanities as a transdisciplinary study concerned with the workings of both man and machine is probably not a coincidence.

Similarly, there are excellent contributions to the topic of models in the humanities out there, such as from the hermeneuticist and historian Gordon Leff, who wrote about *Models inherent in History* around the same time (Leff 1972). While there is certainly more literature available on "models in science", including dedicated encyclopedia articles (e.g. Frigg and Hartmann 2017), that should not obscure the view. If there is something quite specifically relevant to the issue at hand out there, it should take precedence over oft-quoted but marginally related classics and finding it should be the first task of anyone investigating the topic from a particular angle – in this case, that of the Digital Humanities.

4. Consequences

Which brings me back to what I stated earlier. How far does a collective effort to understand the topic at hand carry towards synergy? I think it is an important step in sampling the interdisciplinary status quo – however, only in respect to certain disciplines, given that the experience and the knowledge from a field like cybernetics will be absent (or present) based on the visibility of the discipline itself, not its value for the debate. This is why I am always in favor of featuring more historians. Of course, one would have to find one who specializes in this area first. That might be one of the biggest obstacles facing the Digital Humanities nowadays: The discontinuity of disciplinary tradition.

Secondly, the workshop was highly stimulating intellectually and proved, in my opinion, that the discourse needs not so much widening at this point but sharpening. Primarily in two directions: What types of models exist in the humanities; why and how are they used (even if implicitly)? And how is this relevant for the Digital Humanities, theoretically and practically?

Answering these questions requires a single line of argumentation, one that I am eager to see established as a result of the workshop.

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Arianna Ciula, Øyvind Eide, Cristina Marras & Patrick Sahle (Eds.): Models and Modelling between Digital and Humanities – A Multidisciplinary Perspective.

This Supplement of *Historical Social Research* stems from the contributions on the topic of modelling presented at the workshop "Thinking in Practice", held at Wahn Manor House in Cologne on January 19-20, 2017. With Digital Humanities as starting point, practical examples of model building from different disciplines are considered, with the aim of contributing to the dialogue on modelling from several perspectives. Combined with theoretical considerations, this collection illustrates how the process of modelling is one of coming to know, in which the purpose of each modelling activity and the form in which models are expressed has to be taken into consideration *in tandem*.

The modelling processes presented in this volume belong to specific traditions of scholarly and practical thinking as well as to specific contexts of production and use of models. The claim that supported the project workshop was indeed that establishing connections between different traditions of and approaches toward modelling is vital, whether these connections are complementary or intersectional. The workshop proceedings address an underpinning goal of the research project itself, namely that of examining the nature of the epistemological questions in the different traditions and how they relate to the nature of the modelled objects and the models being created. This collection is an attempt to move beyond simple representational views on modelling in order to understand modelling processes as scholarly and cultural phenomena as such.

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