20 Years After: What in Fact is a Model?

Roland Kaschek*,a

[a] Alpha-Academica

Abstract. *Heinrich C. Mayr, for many years has been a leading proponent of the importance of modelling issues for computing, the GI and the EMISA. On occasion of his 70th. birthday, this paper sheds a light on a number of key modelling issues.*

Keywords. Model • Theory of Modelling • Thesaurus • Reference Modes • Models as Media Content

1 Introduction

Time is a human invention for structuring narratives. It is therefore that we look back into time when we encounter anniversaries in narratives. In narratives concerning modern computing in Germany the name Dr. Dr. h. c. Heinrich C. Mayr figures highly. His 70th. birthday is thus an anniversary to respond to. In particular it means a lot to me personally. I contribute this paper to thank him for the opportunities he gave me.

Heinrich was one of the founding members of the EMISA. He is a long time EMISA-activist and was for many years a leader of the GI. His impact on modern computing in Germany is not second to that of many other colleagues. I wish him very well for any of his future plans and in particular personal well-being.[1]

In 1999, I have addressed the question what a model actually is in this journal as a current catch phrase and turn to this subject again now. I comment on earlier work I started as one of Heinrich's post docs with the then University of Klagenfurt and that I have continued when I was with Massey University in New Zealand. The question, as to what a model actually is, is still being discussed (Sander 2011, Ungermann 2017). I have worked on modelling issues for many years and try to add some new stuff now to that earlier discussion.

How one defines the term model is a question of convenience. In my current view traditional definitions of the term model are not really convincing. I thus in this paper try to contribute to a common ground based on which a more suitable definition might emerge and gain general acceptance. My text (Kaschek 1999) is not available on the EMISA Web site. I thus include a brief summary of its key points in this paper. Right now, I can not go into a full review of the scientific discussion on modelling since 1999. Therefore, I limit myself in this paper to adding some aspects of it that I have introduced since then and to extending or modifying points where that seems appropriate.

2 Basic modelling narratives

From old age, models have been created and used to impact the quality of life. Let it be that an improvement of it was intended, its deterioration was to be prevented from happening or a current state of affairs was to be understood. Models are the result as well as the origin of narratives of a practice related to these livelihoods. The meta practice of handling models may increase the capacity of shaping the related practice. All pursuits start with the most obvious. Thus, modelling starts with using the human body and in particular its limbs in a deictic way. What would be found

* Corresponding author.
E-mail. rolandkaschek@gmail.com

[1] Note that this paper strictly spoken is not a scientific paper, as it contains several views that I do not attempt to prove or even justify.

near by, such as sticks, stones, or similar, probably would have been used too. With sign-systems external to the human body, in particular script, coming into use, models increasingly become a common good, a cultural asset, and the mentioned meta practice becomes a shared one. Obviously that does not mean that all the participants in the meta practice have the same interests in practice or would work on the same task. Further recent remarks concerning origin and history of modelling can be found in (Hesse and Mayr 2008).

Computer-use has become ubiquitous. Therefore software production and use has become a mayor branch of the economy of the developed countries. Computing, among others, contributed to that by providing methods and tools for software development. In particular, it has provided abstractions, that are able to specify the business processes that exist, how they are related to each other, how they are being executed, what data they refer to and how that data is being structured and processed. Together with an increasing capability to provide new or improved products or services, which has contributed to computers penetrating the economy. Many of these abstractions required for this process have been conceptualized as model. Models and modelling, to some extent, can thus be understood as enablers of the modern economy.

The interest of computing in modelling overwhelmingly seems to result from its task, i. e., to schedule men power, financial, organizational and technical means as required for improving or even enabling the business models, services or products of certain organizations, such as corporations or authorities. The shared meta practice chiefly rests on a particular part of the model, the so-called thesaurus, i. e., the list of the definitions of the shared key concepts including the instructions of how to refer to the items potentially corresponding to these concepts. Despite its paramount importance for modelling, to my knowledge, the thesaurus in many modelling approaches and papers on modelling is undervalued.[2] To deal with that, one ought to work on how to produce a usable thesaurus, how to define, measure and improve the quality of a thesaurus.

Attraction and power of the early sense-giving or explanatory narratives probably result from their poetry and mysticism, as well as the authority of those who were in control of those narratives. With the development of technology, the emergence of the division of labour and in particular institutions of education and learning, narratives emerge whose utility transcends the organization of human communities and opens up the space of nature control. However, it nearly goes without saying, that control of nature is an illusion most of the time and in fact is a consequence of decisions to ignore certain aspects of it. Practical control over nature is or extends also, at least potentially, into power over people. The sciences and modelling thus may be objective. They are not neutral, however. An alternative to nature control is available in form of policies to nature appropriation that aim at men's purposefully integration into nature. An assessment of the consequences of using given models, in general only rarely takes place. Furthermore, it would probably be limited to private enterprises and ignore public spaces and communities. Any detrimental consequences of model use, that way, are largely blacked out from the planning that takes place in private enterprises. As much of current modelling is embedded into software projects, that are run by private companies, it is quite likely that one, upon close examination, would find that narratives are emerging or even have already achieved dominance, that consider the interests of users only or mainly from the perspective of companies and thus might develop potential to harm human communities.

The two most obvious idealizing characterizations of an item refer to what it is in itself and to what it is for some individual. What a model is in itself, leads to the question of what its elementary parts are and how these are combined into a whole. What a model is for some individual, leads to the question, which operations the related individual applies to the model. Stachowiak (Stachowiak 1973; Stachowiak 1983; Stachowiak 1992), who

[2] As an example of a modelling paper that entirely ignores the thesaurus is (Hesse and Mayr 2008).

I have used before (Kaschek 1999), with regard to these questions, says that models are sets of predicates and that model users use models to, in a controlled way, refer to something different from the model, i. e., a model original. That reference must be controlled, since it is supposed to enable an information transfer between model and original (and vice versa). This information transfer is potentially beneficial to the model user who even might change their practice because of the model's impact on that practice.

Model use is about an information deficit with regard to some item, a so-called model original: someone wishes to achieve a certain goal with regard to the original. They, however, turn out to be ignorant of some information (subjectively) required for achieving that goal. The key idea to solve this problem is to obtain the required information with regard to the model and then transfer it to the original.[3] For that to be a justifiable option, the model needs to share some of the original's characteristics. To enable the model user to process the model in a way, that provides them with the information needed, the model needs to have appropriate characteristics. Some of these won't be shared with the original. This basic narrative can serve as a justification for Stachowiak's decision to identify three key features of any model, namely the **mapping feature**, the **reduction feature** and the **pragmatic feature**. According to the mapping feature to each model there is an original. According to the reduction feature a model will share some of the original's characteristics, but might miss out on some others. The pragmatic feature finally means that the association of an original to one of its models is not a once and for all established one. Rather, a voluntary decision of the model user introduces or drops that association. Consequently, the model-original relationship is a many-to-many relationship. The originals to a model, sort of, are similar to a quantum cloud of items that may be referred to from the very model. The mentioned information transfer, however, is not a one-way-street. Information about the original feeds the process of model creation. The two mappings applied to accomplish the required information transfers are not necessarily inverse to each other.

The reduction feature requires particular attention since it is in general complemented with an extension feature (already observed by Stachowiak). The feature reduction is due to keeping the model small and at the same time relevant with regard to the pursued goal. However, the model is supposed to undergo certain manipulation or operations that have to be carried out by certain individuals under specified conditions. The model thus in general needs to have characteristics it does not share with an original. As far as I see that crucial point was not observed by Stachowiak. It also is not discussed in (Hesse and Mayr 2008). The extension feature (or, as Stachowiak has referred to it, the abundance of model characteristics over original characteristics) thus is not a defect or accidental feature of models, it is rather essential for models to be able to serve the model users in the intended way.

In retrospection, it occurs to me that Stachowiak can be critiqued for insufficiently dealing with the quality of the model-original reference and the various kinds of such references that occur in modelling. In my view, the quality of model-original references is essentially determined by the thesaurus. So, I think, Stachowiak's theory should be extended by discussions of the thesaurus and what I call reference modes.

After a model user has established a model-original-reference, the information transfer from model to original is about utilizing the model. Modelling thus belongs to what is known as analysis-synthesis cycle. Models usually result from analysis and extend the epistemic, manipulation and control powers concerning the original. The model then may be used to state hypothesis with regard to one of its originals. Changes or invariances with regard to an original may become predictable and an original may become controllable. In any case, the often even huge differences

[3] In the light of this context I hold that information can be defined as any item, that can be fed into a decision procedure, which is supposed to achieve a given goal. See the discussion in (Sloman 2016).

between model and original may result in the mentioned information transfer even being challenged. In particular, because empiric evidence in favour of that transfer may be the only or key evidence justifying that transfer and moreover the model in several ways may even be wrong.[4] However, as long as the model is sufficiently useful one would overlook imperfections or defects of the mentioned kind as long as there is no viable alternative.

Gödel's incompleteness theorems (Boolos et al. 2010), in my view, are the deepest reason for the rise of modelling. These theorems say that (1) the consistency of a sufficiently expressive theory cannot be proven by means of that theory alone and that (2) in a sufficiently expressive consistent theory propositions may be stated, that cannot be proven within that theory. In view of the relative boundaries for establishing shared certainty based on rational narratives, a resorting to shared rules of knowledge discovery and decision making may provide an alternative to relapsing to poetry or mysticism of the basic narratives.

The Gödel theorems, with regard to the epistemic process, imply that its methodological base and its logical foundations have to be adapted continuously if an ever extended understanding and control of nature is intended. These theorems put the ones searching for knowledge about the world into the shoes of a tourist whose car occasionally needs to get fuelled up, in order to get to the desired point of interest.

In narrative based epistemic communities narration traditions may emerge with regard to sensegiving or explanatory narratives. These may even turn into epistemic obstacles, with regard to which modelism may turn out to be useful due to its anarchic unconcern due to its strong fixation at results.

[4] To briefly comment on the relationship between empiric and analytical knowledge, I state my view, that empirical knowledge, in one or another way, is ultimately processed into analytical knowledge. The latter, moreover, in fact may not be really analytical. It rather may be tied to the part of the universe in which it has emerged and might turn out to be utterly useless in distant parts of that very same universe.

3 Reference modes

A number of dimensions can be identified that a discourse on modelling could need to focus on. In this note I, more or less, focus on efficacy and function of a model. In earlier papers (Kaschek and Mayr 1996, 1998) Heinrich and I have discussed tool and method aspects of models, respectively. The dimensions I want to put forward are: **class**, the discourse in this dimension would focus on the various instances of the model, if any are allowed to exist; **context**, the discourse in this dimensions would focus on the methods that employ models; **definition**, the discourse in this dimension would focus on whether the model concept is defined explicitly, implicitly or not at all and if it is defined, what definition is given; **efficacy**, the discourse in this dimension would focus on how well references from a model to its originals can be carried out; **function**, the discourse in this dimension would focus on the kind of reference that is made from a model to its originals; **impact**, the discourse in this dimension would focus on the consequences model use probably has for human individuals and communities; **information**, the discourse in this dimension would focus on the kind, quality and amount of information to be transferred from a model to one of its originals; **object**, the discourse in this dimension would then focus on the ways to conceptualize a model original as an entity, operation, process or similar; **objectivity**, the discourse in this dimension would focus on either understanding a model as an aggregation of multi-perspective constructions or as an in-itself-existing entity; **ontology**, the discourse in this dimension would focus on whether to consider a model as a system of signs, a physical object, an idea or something else; **pragmatics**, the discourse in this dimension would focus on the quality of the model; **state**, the discourse in this dimension would then focus on the life cycle stage a model is in and the operations that therefore appropriately may be used on it and **tools**, the discourse in this dimension would focus on the tools used when dealing with models.

Heinrich used to consider modelling from the point of view of model creation. To some extent, that view might justify focusing on structural aspects of models rather than on the operations model users apply to them. He has structured models into concepts for either items or relationships between items. While that certainly was inspired by the huge popularity of the entity-relationship modelling (Chen 1976), the basic idea also can be applied to object oriented modelling and process modelling. With regard to model usage, however, one would probably want model-handling-operations to be considered as more important. In particular, considering any data structured according to the model would have to be included as it might have to be used for referring to an original. In that regard (Batini et al. 1992) seems to be pioneering work.

A peculiarity of the original-reference from a model can be illustrated nicely using the concept of Turing Machine. In computing, Turing machines are frequently considered as model of the concept of algorithm (Boolos et al. 2010). That, however, does not require a common understanding of algorithms prior to Turing's invention of what is now called Turing machine. Rather, it was essentially the power of Turing's idea of an ideal computing device that helped bring about a consensus regarding what the term algorithm should mean. There are examples for similar circumstances. For example, Yudkin (2012, p. 77) talks about how to find out how the human metabolism processes sugar. To answer that, one would start figuring out and set up an experiment that then will be carried out. The probands, or maybe even the experimentation rules, would then be used as the model. It, however, would not be obvious, what the original should be. In the case of a well-designed experiment, it would probably, as it was in case of the algorithm, constitute the concept of human sugar metabolism.

When, some years back, the concept of ontology was becoming mainstream, I found that this constitutive model-original reference was used there too, i. e., the original was being created by means of a model. Reference modes, that I have identified earlier (Kaschek 2005), are: the **descriptive mode**, the model describes, how the original looks like (photography); **prescriptive mode**, the model describes, how the original has to look like (norm); **constitutive mode**, the model defines the original (ontology); **idealizing mode**, the model specifies the original's ideal state (proceeding model); **prognostic mode**, the model describes a previous or future original state (climate model) and the **explanatory mode**, the model explains certain aspects of the original (Bohr's atom model, Mendeleev's periodic table of elements, . . .).

In my view, the general discussion back then was seriously limited. It essentially ignored the way in which models were being used to refer to originals. It is, however, exactly this reference mode that tells which model original differences (MOD) supposedly are considered essential and what to do about them. This, obviously is what modelling is all about. Rather than attempting to work out the key reference modes, some work (such as Hesse and Mayr 2008) tried to characterize the models that were to be used in those modes. In my view, however, it was clear already a long time ago, that such attempts are futile, as any model can be used any way the model users see fit.

In case of the descriptive reference mode, a non-tolerable MOD has to be dealt with by changing the model. In case of the prescriptive reference mode, the original has to be adapted, however. In case of the constitutive mode, the problem does not occur. In idealizing mode, one might even argue that MODs have to be tolerated because the original fails to be in ideal state and cannot, at acceptable cost, turned into that state. In case of the prognostic mode, it is key that any important MODs essentially disappear at the right point in time. In the explanatory mode, it suffices that any important MODs can be explained by the model presuppositions or can be ignored altogether without challenging the model's explanatory power.

4 Models as media content

In Stachowiak's view, models consist of predicates. I find this view suspicious, as any predicates do not include the perspective from which the original is viewed and ultimately justifies the ascription of the predicates to the original. I think, that an approach to modelling would be superior, that uses judgements to ascribe characteristics to originals as these inherently include the perspective under which the judging individual or community views, i. e., constitutes, the original.[5] Obviously, the way originals are constituted, ultimately carries over to model specification. As theoretical foundation of the theory of judgements, in the past I have used (Pfänder 1921), see also (Kaschek 2004).

Since some time I adhere to Nietzsche's dictum (Nietzsche 1887) that any perception involves a perspective, i. e., involves a peculiar and personal way of constituting conceptually a thing under scrutiny. For that , the distinction of the thing by itself from the thing for someone in my view cannot really be followed through. Rather, in my view, it is a modelling approach of actually rather limited explanatory powers. I think that Nietzsche is also right in asserting that the best that can be hoped for is a multi-perspective perception of scrutinized entities. Therefore, I feel that attempts to structurally characterize models are insufficient. They need to be complemented by some approach that ignores the model structure.

Models can be understood as to facilitate a conversation between the creators and the users of the model. The information transfer mappings mentioned before, can be understood as being implemented by that conversation. Since, in that sense, modelling intimately is connected to a media facilitated communication, at this time I prefer a definition of the model concept as media content. Of course I stick to Stachowiak's model features. Moreover, I add the reference mode and the much increased role of the thesaurus. Considering models as media content makes it superfluous to consider syntactical details when it comes to distinguishing models from non-models, since, what counts simply is, whether or not it a valid media content. It might even help to include into modelling the perspective of model user more effectively than this has been achieved so far. I would not necessarily claim, though, that in each case a given media content is used to refer to something different from it. However, in my view that is actually pretty often the case.

The idea to consider models as media content that facilitates a conversation between model creators and model users suggests to understand the concept of model quality as the consistency of that model that contributes to that conversation being helpful with regard to the model users reaching the goal, that triggered the model use in the first place. At this time I can only contribute most basic related ideas. If one takes a transactional view of communication, according to which communication essentially is an exchange of messages, then, to understand communication one has to understand sequences of messages. (Schulz von Thun 2017) provides a simple, yet powerful, meta model of messages. Schulz von Thun distinguishes the following message dimensions, **content**, **me**, **you** and **appeal**. He, moreover, considers each message as a compound of message aspects according to each of the mentioned dimension.

By the content dimension of a message, an interlocutor expresses what the message actually is about, while in the me-dimension that interlocutor, to some extent and in some way, discloses to their partner how they view themselves and by the you-dimension, expresses, how they perceive and relate to the partner. Finally, in the appeal-dimension, the interlocutor expresses what they want the partner to do in response to the message reception.

Some of the things to be considered with regard to the virtual conversation of model-user with model-creators are: the **kind of item** that may, should, shouldn't or must not be referred to with the aid of the model; the **modes**, in which these items may, should, shouldn't or must not be referred to; the **goals**, that may, should, shouldn't or must not be pursued by means the model; for each

[5] As is well-known, in database integration this view is actually commonly taken.

goal, what are the processes, operations and data that are required to achieve the goal; how to assess the model user's **readiness** to use the model and how to bring that readiness to the required level; and finally, how to identify the **expectations** the model user has with regard to the model and how these can be communicated to the model creator.

It would be interesting to pursue further research with regard to any improvements of the theory of model quality, that can be achieved by considering models as media content. This, however, would have to be the subject of further papers.

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