Computerbased Simulation – New Tools of Knowledge Production

Methods of validation, uncertainty and public mediation

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Abstract

The research project *Computerbased Simulations – New Tools of Knowledge Production* analyses the change of knowledge production in science caused by using computers as scientific tools. The project is focused on two aspects: 1. Methods of validation and the problems of uncertainty; 2. The communication to the public of scientific results produced by computer simulation. Based on case studies in the fields of genetics and climate research, the empirical study will investigate the attitudes and motivations of researchers making simulation based results valid and communicating this results in an adequate way to the public.

The research project is part of the broader initiative "*Science Policy Studies*", which was initiated by the Federal Ministry of Research in 2001 and is carried out by the Berlin-Brandenburgischen Akademie der Wissenschaften. The initiative is located in the field of science studies and connects approximately a dozen projects from various universities and institutes in Germany.

Project Description

Since the 1950´s computer simulations are used in science. Expanding computer capacities, the development of simulation tools and algorithms, and increasing complex visualisation technologies establish computer simulations as powerful instruments of scientific knowledge production beside theory and experimentation. Regarding simulations as activities in a virtual laboratory setting – comparable to experimenting in a laboratory setting – this way of knowledge production is determined by various conditions: the digital and algorithmic processing of data, modelling and using computer power to run the models. These conditions restrict the simulation based knowledge production and lead to a methodological inherent potential of uncertainty. The efforts to keep the uncertainties in an acceptable limit of error tolerance force the focal question about the methods and practises to construct the simulation models and to validate the results. To investigate these methods and practises the research project will focus the following aspects:

- Model construction: Empirical study of the construction of simulation models in genetic and climate research; Investigation of the advantages and disadvantages of simple respectively complex models

- Validation: Empirical study of the methods and practises to validate the results in genetic and climate research; Developing a matrix of ways of validation and a typology of uncertainties; Study of former models in climate research to show the development of validation structures.

- Public Communication: Empirical study of scientist's awareness of communication to the public; Discussion of the uncertainty question and the limit of communicating the problems of uncertainties to the public.

Case Studies

The project is based on case studies. For these case studies the fields of genetics and climate research were chosen motivated by the huge public interest in both disciplines and an interesting phenomenon being observed in genetics as in climate research. Despite the specifity of each simulation two major strategies of simulating have been recognized: The use of simple models and those of higher complexity. Simple models allow the scientists to study the model behaviour in all aspects, more complex models enable the introduction of parameters and processes of a greater realistic context than simple ones do. This implies various consequences for the validity and range of simulation results which will be analysed during the project.

Genetics / Biology of Cells

The first group of scientists observed and interviewed are the group of Prof. Hans-Peter Herzel at the Humboldt University of Berlin, Institut of Theoretical Biology. This group is part of a broader network together with the Charité Berlin, the Max Planck Institute of Molecular Genetics in Berlin and the Max Delbrück Center Berlin-Buch. Three main simulation projects will be focused: Simulation of signal transduction in cells, modelling of circadian rhythms and reconstruction of "gene regulated networks" from empirical array data for the Chorea Huntington disease. The use of simple models is typical for the researchers work. Unlike the Max Planck Institute of the Dynamics of Complex Systems in Magdeburg that is well known for the use of complex models: The research group of Prof. Ernst Dieter Gilles are simulating the cell cycles and they will be the counter group of this study.

Climate Research

The phenomenon of simple respectively complex models determines also the choice for the research groups in the field of climate research. The researchers around Dr. Johann Feichter at the Max Planck Institute of Climate Research in Hamburg investigate the influence of aerosols on the climate. They work with complex models to reach the most realistic results possible. Others such as the Potsdam Institute of Climate Research use simpler ones like "models of intermediated complexity" to study the sensitiveness of the models behaviour.

Two time periods, each of a half year, are planned to observe and interview the research groups, to study their internal presentations and publications, and – in the field of climate research – to analyse older models to investigate the increasing complexity of modelling the climate and the growing impact on the public attention.

Theoretical Context

The results of the empirical study will be discussed in the recent theoretical context. Above all, during the last years simulation became an issue of science studies (US: Winsberg 1999, 2001, 2003; Sismondo 1999, 2001; Norton/Suppe 2001; Casti 1997; Galison 1996; Germany/Switzerland: Hartmann 1995, 1996; Schmidt 2000, 2002; Stäudner 1998; Klein 2001; Warnke 2002, Ahrweiler/Gilbert 1998, Merz 2002). Especially Peter Galison´s idea of the "trading zones" (Galison 1996) as an alternative to Michael Gibbons´s concept of "transdisciplinearty" (Gibbons et al. 1994) can possibly be utilized for a pragmatic view on the construction and validation manners in computational science. An extremely interesting focus is the chance to recontextualize science posed by simulation. But post modern, context sensitive science (Bnoß et al. 1993; Gibbons et al. 1994, Nowotny et al. 2001) has to sacrifice scientific accuracy. The methodological paradox that increasing complexity doesn't lead to increasing exactitude in forecast is the recent mystery of modern science and its uncertainty. Looking at concepts of model theory, epistemology and computer theory the mystery dissolves in a concession to a pragmatic and computable handling of models and simulations.

Gabriele Gramelsberger - Scientific Background

Since 1995 computer based simulation and visualization defines my research topic. Starting with a magisteral thesis on "Theory, Simulation, Experiment" – an epistemological study on the use of computer simulation to expand explanation and forecast possibilities in science, based on interviews with researchers – at the University of Augsburg (1996 by Prof. Dr. Klaus Mainzer, Department of Philosophy and Theory of Science), I deepened the issue on a semiotic view during my doctoral thesis "Semiotics and Simulation" at the Free University of Berlin (1998 - 2001 by Prof. Dr. Sybille Krämer, Institute of Philosophy). The computer as a semiotic machine manipulating data and the computer simulation as a semiotic practise producing in silico data changed the scientific foundations irrevocable. No longer are facts the base of scientific knowledge production, but data.

The production of a study in 2001 and one in 2003/2004 about "Computer Simulations – New Tools of Knowledge Production in Science" led me to the field of science studies. Both investigations were part of the initiative "Science Policy Studies" of the Federal Ministry of Research carried out by the Berlin-Brandenburgischen Akademie der Wissenschaften. The afore mentioned research project leads on from the preparatory studies and will be carried out in the next tree years at the Free University Berlin (2004 – 2007).

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