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Verification and Validation in Social Simulation: Patterns and Clarification of Terminology Used

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Introduction and Goals

The terms verification and validation (V&V) are used commonly in science, often with the same or interchangeable meanings. The meaning of these terms has always been controversial in natural science and particularly in simulation in the natural sciences[1]. In social science simulation, the most common meanings of V&V seem to be imported from technical and numerical simulation[2], having intended distinct, but not surprisingly ambiguous, meanings. The apparent reason

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[1] See Oreskes el al. (1994).

[2] Numerical simulation refers to computer simulation for finding solutions to mathematical models, particularly for cases in which mathematics does not yield analytical solutions, such as dynamic system analysis where specifications are in the form of mathematical models. Technical simulation means simulation with numerical models in computational sciences and engineering. For an historical perspective on the relationship between numerical simulation and the social sciences see Troitzsch (1997).

for distinguishing between the two terms in computer science, and hence in social simulation, is the need to determine the adequacy[3] of certain representations having two distinct subjects of inquiry.

Therefore, the role of verification, in the sense of computer science and engineering, should be the testing of adequacy among conceptual models, program specifications and program code with the ultimate subject of inquiry, i.e. the actual behaviour of the program in physical computers. The role of validation should be the testing of adequacy of those same representations with the subjects of inquiry that they presumably represent, such as the natural or social worlds, or any arbitrary expectation of stakeholders or simulation end-users, i.e. the target social theory or phenomenon.

However, the use of the term “verification” deserves an important observation. In computer science the term originated from the mathematical tradition of classical computational theory, associated with research in formal techniques for proving the correctness of a given program.[4] Nevertheless, insofar as the term also represents the process of testing the empirical adequacy of the behaviours of program in computers, its use has been criticised in the computer science literature itself.[5] Despite the ambiguity of the term for someone unfamiliar with computer science – as often is the case for social scientists new in the field of social simulation – its use is generalized and is not expected to change.

The lack of large consensus with respect to what scientific knowledge is, what it represents or even how it should be used suggests that the terms represented by V&V will never be completely free from a certain degree of ambiguity. Nevertheless, the ambiguity is somehow more salient in social simulation insofar as researchers in this field sometimes need to conflate the computer science technical meanings of those terms with general or specific meanings from the social sciences. In this presentation, concrete examples will be used to demonstrate the common usage of these terms in different contexts with different intended meanings, which often increases confusion.[6] Notwithstanding, a significant number of specific definitions of verification and validation have been suggested in the literature on social simulation.[7] Adopting the meanings from numerical simulation and mapping them to applications in social simulation appears to be the most commonly used solution. References of simulation in engineering, such as Sargent (1998) or Balci (2002), are often used as the

[3] The term “adequacy” itself involves different interpretations of the nature of scientific knowledge, or about different kinds or categories of knowledge. For instance, in social science simulation we may speak about empirical adequacy and also of intentional adequacy. See David et al. (2005) and David et al. (2006).

[4] A program is considered correct in relation to a given specification P(I)->O. The goal is to use deductive procedures to verify conclusively the correctness of a program P in relation to a specification, in order to guarantee that the computation of P with inputs I results exactly into the specified outputs O.

[5] For a critique on the term “verification” in computer science see Smith (1995).

[6] For instance, compare the meanings ascribed in Gilbert and Troizsch (1999, pp.21-24) with definitions suggested in Edmonds (2003, p.108) or Axelrod (1997). The usage of terminology is probably even more confusing for someone unfamiliar with simulation in the social sciences.

[7] To name just a few: Gilbert and Troitzsch (1997), Axelrod (1999), Edmonds (2003), David et al. (2005).

inspiration in this context.[8] However, not even in the discipline of numerical simulation are the terms freed of ambiguities, which appear to result from conflating the computer science meanings of the terms with other specific or general meanings in science. Indeed, whether the terminological mapping from numerical simulation to social simulation is an appropriate solution it depends on how well the methodology (and methods) of technical and numerical simulation can be mapped to the methodology of social simulation.[9]

Because the terms used in technical and numerical simulation were adopted from computer science, analysing the terms according to sound methodological concepts of computer science, and confronting the meanings with current usage in social science simulation, should provide clarification. The clarification of terminology and meaning of these terms in the field of social simulation will be the goal of this communication.

Whereas both terms are connected to others involving various epistemological positions, such as the concepts of adequacy or truth, it will be suggested that it is possible to identify common patterns of methodological goals in the literature, and possible to circumscribe a consensual use of the terms. Thus, for instance – and having in mind the last EPOS workshop –, regardless of viewing simulation as an empirical methodology[10], imitation[11], stylized facts[12], or intentional adequacy between theory and programs[13], the goal of this presentation consists of proposing a terminological reference that provides a common understanding of the intended meaning of validation and verification in social scientific simulation, similarly to their counterpart usage in computer science and simulation in engineering.

The Structure and Intended Contributions of the Communication

The presentation will consist of three main parts. First, the current use of the terms ‘verification’ and ‘validation’ in the natural sciences, social sciences and computer sciences, will be described. In the second part, a survey of the literature on social simulation will be presented along with concrete examples that the terms suffer from considerable ambiguity, which may even result in misleading interpretations when models and/or results are compared in the literature. Several perspectives on the meaning of these terms will be examined, including the social simulation methodological and epistemological essays of Gilbert and Troitzsch (1999), Edmonds (2003), David et al. (2005), Carley (1996; 1999), and Drougol et al. (2003), among others; the technical perspectives of both Sargent (1998) and Balci (2002); the natural science and philosophy of science perspective posit by

[8] Carley (1996), for instance, seems to base her essay on validating computation models entirely on the work of Balci (2002).

[9] The tendency in the literature seems to acknowledge that the logic of the method of simulation in the social sciences does not draw on the logic of the method of simulation in the natural sciences. See e.g. Küppers and Lenhard (2005) and David et al. (2005), among others.

[10] See Edmonds and Moss (2005).

[11] See Küppers and Lenhard (2005).

[12] See Bernd et al. (2005).

[13] See David et al. (2005).

Oreskes et al. (1994) will also be examined along with other applied social simulation examples from the literature.

Third, the presentation will demonstrate that the usage of the terms in social simulation denotes a broader methodological significance than their technical usage in computer science; and that the former encompasses the latter. Particular emphasis will be given to the importance of recognizing the construction of two distinct kinds of conceptual models in the simulation development process, one before the implementation and execution of the simulation programs – *the pre-computational model* – and another after the implementation and execution – *the post-computational model*. These conceptual models may not necessarily be "computable" in the classical sense of the Church-Turing thesis. Any alternative conception of computation may be considered.

This somehow obvious distinction among pre-computational, post-computational and actual computerised models does not appear to be methodologically relevant in computer science or technical simulation, but its tacitness seems to contribute to increased ambiguity in usage of the terms in social simulation. Conversely, such an explicit distinction disambiguates the meaning of verifying the implementation of the pre-computational model in terms of program code (a priori, before execution) and verifying the constructed post-computational model in terms of actual program behaviour (a posteriori, after execution) – while in both cases the subject of inquiry is the computerized model. Moreover, it is able to clarify the distinction between validating the constructed pre-computational model (before implementation) and validating the constructed post-computational model (after implementation) – while in both cases the subject of inquiry is the target social phenomena. Hence, after considering both the informal usage of the terms verification and validation in the social sciences and the technical usage in computer science, the meaning of the terms in social simulation will be defined or circumscribed in the final part of the presentation.

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