
ELEMENTS OF CLIENT CONFIDENCE IN SYSTEM DYNAMICS INTERVENTIONS: A CASE-BASED ETHNOGRAPHIC STUDY

Jason Yves Markham
Victoria University of Wellington, NZ

Acknowledgements

Associate Professor John Davies & Arun Elias, PhD (Masters thesis supervisors)

Despite ongoing debate (Pala, Vennix & Kleijnen, 1999) about the validity of system dynamics models, confidence in the broader model-building intervention has not been systematically explored from the client's perspective. The aim of this research was to develop a descriptive framework of client confidence, while studying ethnographically a system dynamics intervention for a military workforce planning problem. Framing methodology from Russo & Schoemaker (1989) was used to elicit the confidence criteria during client interviews, while constant comparative analysis methodology, as defined by Glaser & Strauss (1967), was used to construct the descriptive framework. The observed views of client confidence appeared to be extensive and diverse throughout the model-building intervention, and although client confidence proved to be an 'elusive' concept (Mitroff, 1969), framing methodology served as an effective filter for eliciting these elements.

Introduction

The technical perspective of the model builder, namely the 'validity' of model-building products, has dominated system dynamics research and model-building. The client's 'confidence' in the outcome of the model-based intervention, as the ultimate judge of its outcome (Coyle & Exelby, 2000), has been consequently neglected. Given that the model builder must 'build' (Forrester & Senge, 1980) and 'boost' (Coyle, 1996) the confidence of the client(s), there should be some methodology for determining the elements of client confidence. This research contributes to this need by demonstrating the use of framing methodology and content analysis as a multidisciplinary approach to the construction and interpretation of client confidence. This paper also makes a theoretical contribution of the confidence themes for this case study.

A comparison of existing frameworks of confidence themes is included in Table 1, matched to the 24 confidence themes developed during this study. These frameworks have been organized under four perspectives of confidence, along the epistemological spectrum from relativism to positivism. These four

perspectives were drawn from three key philosophical papers of system dynamics and operations research literature: Naylor & Finger (1967), Barlas & Carpenter (1990) and Déry, Landry & Banville (1993).

Grappling with the Concept of Client Confidence

Confidence is subjective and relative to the client (Zhu et al., 1995), rather than having an absolute meaning, as suggested by the term validity (Forrester & Senge, 1980). It also became clear from this study that clients ‘don’t talk about validity’, because the concept is unfamiliar and difficult to conceive. Selecting an appropriate research methodology to elicit these client views was therefore critical to the results of this study.

There is widespread doubt whether model builders typically conduct sufficient formal model tests (see for example Robinson, 1980; and Wakeland & Hoarfrost, 2005) and only broad advice about how to use these tests or convey their results to clients. Van der Zouwen has demonstrated that it is ‘very difficult’ to assess the validity of models ‘on the basis of their output only’ (1997: 852). In the absence of ‘objective quantitative methods ... for determining the validity of models from the viewpoint of the (client)’ (Forrester, 1973: 35), it therefore becomes a matter of the client’s judgement about the model-building intervention.

Framing methodology is useful in this situation because it provides a cognitive structure that sensitizes the observer to other perspectives (Davies & Mabin, 2001). Unlike model builders, who will tend to approach the issue of model validity with uniform, a priori notions (Meadows, 1980), clients will lack the a common or development mental framework for thinking about the qualities of an intervention. When De Bono (1971) investigated empirically the situation where non-experts were required to explain the behavior of a ‘black box’ technical phenomenon, he concluded that an individual’s evaluation follows rules of ‘everyday thinking’. The paradox of this pragmatism is that each client of a technical project will be right in their own view, but no one client will be completely right. Therefore, because all client views should be considered legitimate, framing was identified as a suitable methodology for obtaining the views of each client.

Research Methodology

The chronology and relationships between the research methodologies and techniques used in this case study are shown in Figure 1, demonstrating its multi-methodological character. The principal clients for the system dynamics intervention were identified using stakeholder analysis and interviewed prior to and immediately following the key stages of qualitative and quantitative model-building. Framing methodology was used to structure the interviews, which were then analyzed by a modified version of content analysis, known as ‘constant comparative analysis’ (Glaser & Strauss, 1967). This technique was used to construct a descriptive framework of the concept of client confidence, using as a foundation the four-part spectrum of perspectives of confidence identified from the literature of system dynamics (refer Table 1):

Perspectives of	Observed Client Confidence	'Desirable characteristics'	'Measures of validity'	'Quality criteria'
Confidence (Refer note 1)	Themes (Refer note 2)	Source: Randers (1980, p. xix)	Source: Lane (1995, p. 125)	Source: Coyle (1996, pp. 353-354)
Relativity	Affect			
	Discourse		Meaningfulness & communicability	
	Satisfaction			
	Significance	Relevance	Relevance	
	Subjectivity		Cultural congruence	
	Trust		Trustworthiness	Credibility
Utility	Agency		System improvement	
	Benefit	Fertility	Fertility	Creativity
	Cost		Time & cost	Cost
	Model use			
	Suitability		Precision of insights	Suitability
	Solvency		Operational validity	Productivity
	Usability	Transparency	Ease of enrichment	Flexibility, simplicity & transparency
	Usefulness		Usefulness of intervention	Purpose
Empiricism	Accuracy	Formal correspondence with data & point predictive ability	Data validity	
	Analysis		Analytical quality	
	Experiment		Experimental validity	Sensitivity
	Fidelity	Descriptive realism & mode reproduction ability	Conceptual validity	Generality
Rationality	Caveat			
	Expertise		Guru status	
	Logic		Formulational validity	Basis
	Sophistication			Redundancy
	Soundness		Rigour & robustness	Promotion
	Understanding	Insight generating capacity	Insight generating	

Note 1. Adapted from Naylor & Finger, 1967; Barlas & Carpenter, 1990; and Déry et al., 1993.

Note 2. Observed during the study and developed into a framework using ground theory.

Note 3. Shading indicates new confidence themes.

Table 1 Comparison of Frameworks for Confidence in System Dynamics Interventions

relativity, utility, rationalism and empiricism. In the final phase of this study, the descriptive framework was used as a sensitizing framework to interpret and compare the views of each client at each key stage of the model-building project.

This enquiry occurred during a system dynamics model-building intervention intended to identify policy leverage points for a military workforce planning problem. The model-based intervention was conducted along similar lines to the methodology described in Maani & Cavana (2000) and the framing interviews were scheduled at three key stages during the model-based intervention, as shown in Figure 2. The iterative nature of system dynamics model-building is evident in Figure 2 from the occurrence of problem structuring and model testing activities during almost all stages of the project.

A semi-structured interview format was used in this study (after Cavana, Delahaye & Sekaran, 2001), based on the frame analysis questions shown in Figure 3. The clients were given a copy of the interview questions before the interview, to counter their lack of familiarity with the technique.

The idea of framing is commonly attributed to Erving Goffman's text *Frame Analysis* (1974, revised 1986), however those ideas have remained conceptually unclear (Gamsom, 1974) and 'vague' (Scheff, 2005). Russo & Schoemaker's book *Decision Traps* (1989) have cast framing into an explicit and unambiguous technique intended to serve as a tool for managers. The 10 frame analysis questions are intended by Russo & Schoemaker (1989) to help managers avoid their own *frame blindness* and lack of *frame control*. This study used the same set of frame analysis questions with slight modifications by Davies & Mabin (2001). These questions focus on the symbolic (*boundaries, yardsticks, reference points, metaphors, highlight and shadow*) and social (*why this frame, what others think and slogan*) elements of framing.

Ethnography means the study of a group from the 'inside', where the researcher comes to be regarded as 'one of them' (Rosenthal & Rosnow, 1991). This research context proved suitable for me because it was a continuation of my professional experience as a part-time system dynamics model builder in a military organization. This choice of research design was intended to improve the chances of success for this model-building intervention by ensuring it proceeded in an iterative fashion (Homer, 1996) and was conducive to my reflective involvement with the clients (Sterman, 2000).

A technique of content analysis known as constant comparative analysis was used to develop the confidence themes, following the steps described by Cavana et al. (2001: 171-175). Content analysis is an intensive, reflective coding methodology for developing grounded theory and was conducted in four phases, as shown in Table 2.

During the first reading of the interview transcripts, distinct confidence criteria (or 'sub-themes') were identified and grouped into preliminary themes (open coding). Then on the second reading for axial coding, the sub-themes were refined, expanded and reorganized. Selective coding, during the third reading of the data, was the main opportunity for simplification of the themes, concluding with the allocation of themes to the four meta-themes (or 'perspectives').

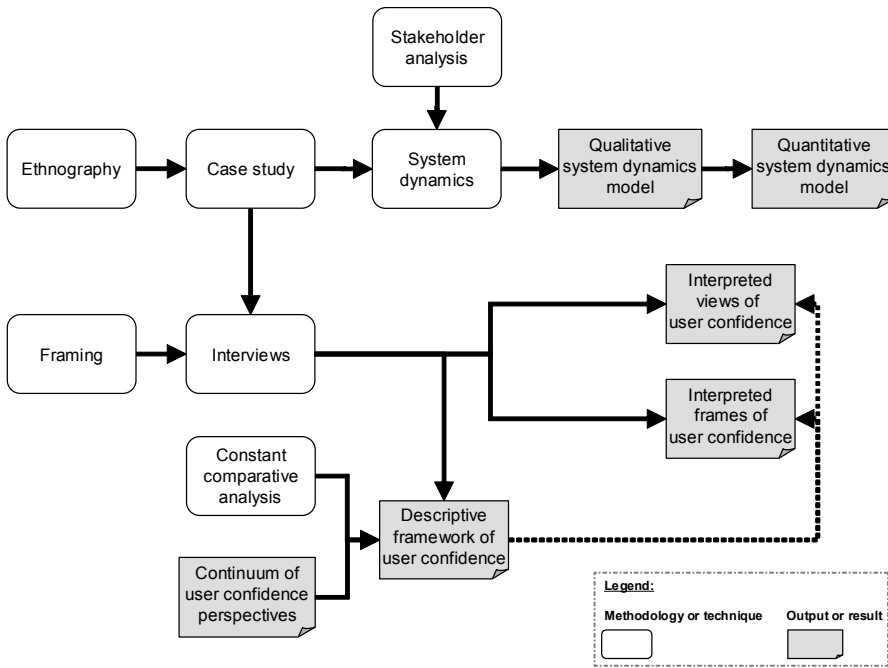


Figure 1 Research Methodologies and Techniques

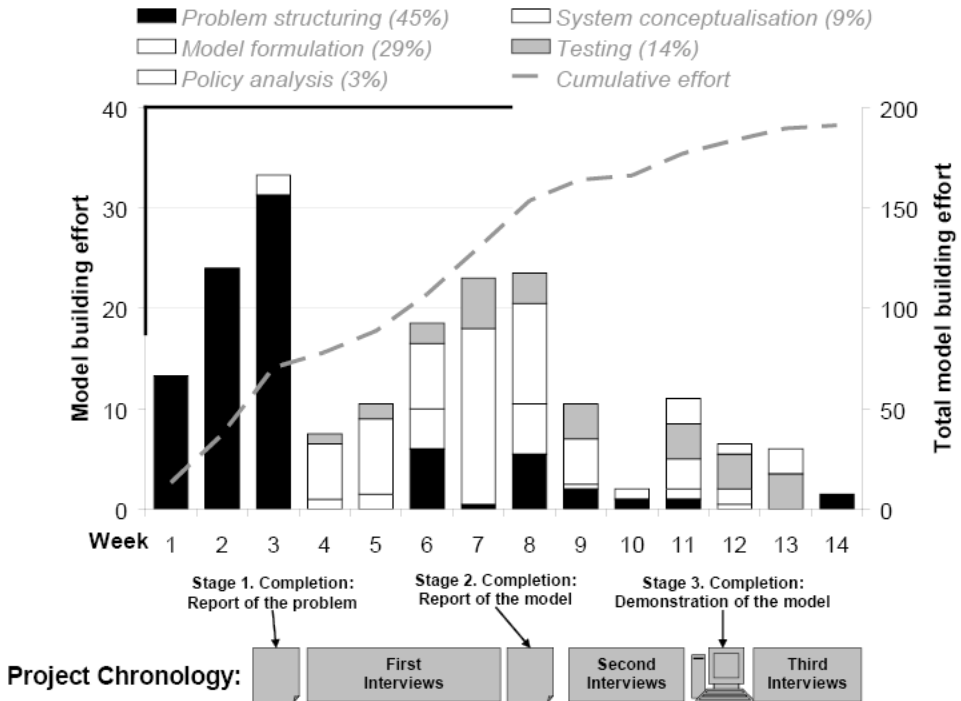


Figure 2 Chronology of Model-Building and Framing Interviews

FRAME ANALYSIS WORKSHEET

1. What issue or issues does your view of validity address? In other words, what are your validity criteria?
2. What boundaries do you put on the issue of validity? In other words, what other aspects of validity are left out of consideration?
3. What targets or reference points do you identify as success or failure, for the development and use of this workforce model?
4. What measures or scales do you use in conjunction with these targets?
5. Why do you think about the issue of the model’s validity the way you do?
6. What does your view of validity emphasize or highlight?
7. What does your view of validity minimize or shadow?
8. Do other people in the Army or workforce planning think about the issue of validity differently from the way you do?
9. What metaphors—if any—do you use in thinking about the issue of validity?
10. Can you summarize your view of validity in a slogan?

Source: *Davies & Mabin (2001: 76); adapted from Russo and Schoemaker (1989: 43)*

Figure 3 *Frame Analysis Questions*

Stage of analysis	Analytical focus
Open coding	Development of ‘themes’
Axial coding	Development of ‘sub-themes’
Selective coding	Development of ‘meta-themes’
Description of client views and frames	Integration and refinement of thematic levels

Table 2 *Stages of Content Analysis*

A fourth and final reading was undertaken to verify the confidence themes for each client and interpret the client frames, allowing for final adjustments and refinement of the descriptive framework. This process of constant comparative analysis became a living, ongoing activity that continues during this reporting stage of research and is likely to unfold further as further insights and meanings arise from reflection on the data and framework.

Results and Findings

Descriptive Framework of Client Confidence

The descriptive framework contained 120 distinct confidence criteria (i.e. ‘sub-themes’). The confidence criteria were clustered into 24 ‘themes’, each defined by a ‘rule for inclusion’ (Cavana et al., 2001). Those 24 themes were placed on the spectrum of perspectives of confidence (refer Table 1). This framework is clearly extensive because it includes all the explicit themes from existing frameworks (refer Table 1), while also identifying four new themes.

The ‘mega-themes’ of *proof* and *relevance* were included to highlight the perspectival extremes of the positivist-relativist spectrum. This idea reso-

nates with the contrasting ideas of *representativeness* and *usefulness* proposed by Shannon (1975), has been extended by Lane (1995), and is also apparent in the title of Sterman's validation chapter: 'truth and beauty' (2000: 845). I attribute the notion of *proof* to Naylor & Finger (1967) for proposing a theory of validation by prediction based on *rationalism* and *empiricism*. This spectrum of confidence from *relevance* to *proof* demonstrates empirically the diverse range of elements within the notion of client confidence.

The themes of client confidence constructed in this study appear to fit isomorphically with Lane's (1995) more comprehensive framework. Although there are fewer thematic matches with the frameworks of Coyle (1996) and Randers (1980), the themes from this case study appear to be more extensive. This research generated four previously tacit themes of client confidence: *affect*, *model use*, *satisfaction* and *caveat*.

Tacit Themes of Client Confidence

The client confidence theme of *affect* was defined in this study as an 'emotional response towards the model, either positive or negative', demonstrated by the client comment: 'I am excited by this (model)'. The sub-themes for *affect* were *excitement*, *enthusiasm*, *encouraging* and *surprise*. Although Coyle, Exelby & Holt have also cited client enthusiasm as a confidence criterion (1999), authors have generally excluded the element of *affect* from the concept of client confidence.

The theme of *model use* was defined as 'employment of the model, including support or requests for further model-building effort', with its sub-themes being *implementation*, *operation*, *demand* and *support*. A common client statement for this theme was 'I am going to use it', similar to Forrester's idea that 'the validity and usefulness of dynamic models should be judged, not against an imaginary perfection, but in comparison with the mental and descriptive models which we would otherwise use' (1968: 3-3). By its frequent omission from the literature of confidence and validity, it appears the element of *model use* has been treated as external to the issue of client confidence.

Satisfaction was constructed as a theme of client confidence for data matching the description 'fulfillment of a desire'. One client expressed this idea in terms of the model results being 'within a bull's road of what I want'. *Satisfaction* is related to Lane's (1995) validity measure of *cultural congruence*, judging from the sub-themes of *acceptance*, *adequacy* and *intuitiveness*. Most of these ideas about client confidence have appeared in operations research literature, although not explicitly in any framework. For example: 'the model is "good enough" given the purpose' (Van der Zouwen, 1997: 850), '(the client's) satisfaction is a sufficient condition' (Roberts, 1978: 80), 'acceptable level of confidence' (Mihram, 1972: 25) and 'the model's accuracy is within its acceptable range' (Sargent, 2005: 130).

Caveat was defined as 'the bounds of client confidence in the model' with the sub-themes: *limitations*, *strengths & weaknesses*, *limited liability*, *unknown* and *control limit*. There was a significant volume of interview data for this theme covering a wide range of ideas. A few key examples of these ideas are:

Mega-themes	Meta-themes, or Perspectives	Themes
RELEVANCE	Relativity The art or aesthetics of model-building, i.e. personal confidence ⁷	Affect Discourse Satisfaction Significance Subjectivity Trust
	Utility The ends or purpose of model-building, i.e. practical confidence	Agency Benefit Cost Model use Solvency Suitability Usability Usefulness
PROOF	Empiricism The science, validity or truth of model- building (a posteriori), i.e. scientific/ observed confidence	Accuracy Analysis Experiment Fidelity
	Rationality The verity or compliance with rules of model-building (a priori), i.e. reasoned confidence	Caveat Expertise Logic Sophistication Soundness Understanding

Table 3 Summary of the Descriptive Framework of Client Confidence

‘garbage in ... garbage out’, ‘(use the model) at your own risk’, ‘notwithstanding anomalies’, ‘I don’t know what I don’t know’, ‘we just cannot control or understand so many things’, ‘not even a sophisticated model could have taken it into account’, and ‘there could be things that happen that we just have absolutely no knowledge or control about’. Forrester recognized the element of *caveat* when he stated that ‘the validity of industrial dynamics models is not separable from the effectiveness of industrial dynamics as a total viewpoint and discipline.’ (1961, 115).

A notable common feature of these four themes is that they did not emerge from the data until the axial coding phase (refer to Table 2), appearing as ideas on their own merit after the simpler and more obvious themes had been clarified and refined. This result suggests that the concept of client confidence may be more extensive and complex than has been assumed. Framing methodology proved useful in this regard because it sensitized the model-builder, as an action researcher, to the quite complex themes of client confidence.

Observed Client Views of Confidence

The results of observed views and frames of all clients in this case study are included in the appendix, available on request. The three main columns represent the stages of interviewing; at an initial ‘pre-model’ stage, after the ‘qualitative model’ and finally after the ‘quantitative model’. From this summary, I observed

that each client's confidence themes, represented by 'x', tended to crystallize after they had seen the quantitative model. This result was expected because the clients had little or no prior experience with system dynamics. However, no clear pattern of thematic structure or development was apparent from longitudinal or cross-sectional comparisons of client views, suggesting that additional analytical methods might be needed to interpret these results.

The concept of client confidence also grew in complexity as it was explored. For some clients the idea of confidence became difficult to conceive, as illustrated by the statement: '...there are a lot of things that I think are important... I can't think this time, because the more I look at it the more things that are important...'. Most clients perceived confidence as a vague, ambiguous and confusing idea. For example: 'I am a little bit confused about validity as a concept.' These statements demonstrate, just as Mitroff (1969) discovered, that the concept of client confidence towards a computer-based management intervention can be 'elusive'.

Conclusions

A descriptive framework for the concept of client confidence in a system dynamics intervention was constructed from empirical data, with themes ranging across the positivist-relativist spectrum of perspectives. The framework from this study was extensive and diverse in nature.

The concept of client confidence was difficult to elicit and interpret, for the apparent reason that clients 'don't talk about validity'. This supports Mitroff's (1969) empirical finding that the concept of confidence in a computer model is 'elusive'. This case study also demonstrates the ability of framing methodology to deal with this conceptual elusiveness by acting as an 'interpretive filter' (Davies & Mabin, 2001).

Four previously tacit themes of client confidence were included in the framework of client confidence: *affect*, *model use*, *satisfaction*, and *caveat*. As the first three themes fall under the meta-theme of relevance, it highlights the need for model-builders to account for the relativist perspectives of their clients. Finally, this study has demonstrated the use of framing methodology as a 'sensitizing framework' (Davies & Mabin, 2001) to make explicit the elements underlying the elusive concept of client confidence.

It is hoped this research contribution will help to address the need for 'formal criteria for the establishment of confidence in, or the "validation" of, system dynamics models' (Coyle & Exelby, 2000: 27) that are aligned with client views of confidence. This paper may also serve to extend the debate about system dynamics validity beyond the traditional positivist paradigm common to model builders (Berends & Romme, 1999).

Implications for Research

This exploratory study could be extended by explanatory investigation of the concept of client confidence, by constructing a theoretical framework for the relationships between themes. This would involve tracing the explanatory connections between confidence themes, as described in Cavana et al. (2001).

Further analysis might also look at the dependence of confidence themes on exogenous variables, to explore the potential for a typology of system dynamics clients.

Naturally, this case study has limited generalizability, being a study of the principal clients of a system dynamics intervention for a strategic military workforce planning problem in New Zealand.

References

- Barlas, Y., and Carpenter, S. (1990). "Philosophical roots of model validation: Two paradigms," *System Dynamics Review*, ISSN 0883-7066, 6(2): pp. 148-166.
- Berends, P., and Romme, G. (1999). "Simulation as a research tool in management studies," *European Management Journal*, ISSN 0263-2373, 17(6): pp. 576-583.
- Cavana, R.Y., Delahaye, B.L., and Sekaran, U. (2001). *Applied Business Research: Qualitative and Quantitative Methods*, ISBN 0471341266.
- Coyle, R.G. (1996). *System Dynamics Modelling: A Practical Approach*, ISBN 0412617102.
- Coyle, R.G., and Exelby, D. (2000). "The validation of commercial system dynamics models," *System Dynamics Review*, ISSN 0883-7066, 16: pp. 27-41.
- Coyle, R.G., Exelby, D., and Holt, J. (1999). System dynamics in defence analysis: Some case studies. *Journal of the Operational Research Society*, ISSN 0160-5682, 50(4): pp. 372-382.
- Davies, J., and Mabin, V.J. (2001). "Knowledge management and the framing of information: A contribution to OR/MS practice and pedagogy," *Journal of the Operational Research Society*, ISSN 0160-5682, 52: pp. 856-872.
- De Bono, E. (1971). *Practical Thinking*, ISBN 0140137831.
- Déry, R., Landry, M., and Banville, C. (1993). Revisiting the issue of model validation in OR: An epistemological view. *European Journal of Operational Research*, ISSN 0377-2217, 66: pp. 168-183.
- Forrester, J.W. (1961). *Industrial Dynamics*, ISBN 1883823366.
- Forrester, J.W. (1968). *Principles of Systems*, ISBN 0262560178.
- Forrester, J.W. (1973). "Confidence in models of social behavior with emphasis on system dynamics models." Unpublished paper no. D-1967. Cambridge, MA: MIT.
- Forrester, J.W. and Senge, P. (1980). "Tests for building confidence in system dynamics models," *TIMS Studies in the Management Sciences*, 14: pp. 209-228
- Glaser, B.G. and Strauss, A.L. (1967). *The Discovery of Grounded Theory*, ISBN 0202302601.
- Goffman, E. 1974 (1986), *Frame Analysis: An Essay on the Organization of Experience*, ISBN 9780930350918.
- Homer, J.B. (1997). "Structure, data and compelling conclusions: Notes from the field," (1997 Jay W. Forrester award lecture), *System Dynamics Review*, ISSN 0883-7066, 13(4): pp. 293-309.
- Lane, D.C. (1995). The folding star: A comparative reframing and extension of validity concepts in system dynamics. *International System Dynamics Conference*: pp. 111-130.
- Maani, K. and Cavana, R.Y. (2000). *Systems Thinking and Modelling: Understanding Change and Complexity*, ISBN 1-877258-00-8.
- Meadows, D.H. (1980). "The unavoidable a priori". In J. Randers (Ed.) *Elements of the System Dynamics Method*, ISBN 1-883823-44-7: pp. 23-57.
- Mihram, G.A. (1972). "Some practical aspects of the verification and validation of simulation models," *Operational Research Quarterly*, ISSN 1473-2858, 23(1): pp. 17-

- 29.
- Mitroff, I.I. (1969). "Fundamental issues in the simulation of human behavior: A case in the strategy of behavioural science," *Management Sciences*, ISSN 1816-6075, 15(12): pp. B635-B650.
- Naylor, T.H. and Finger, J.M. (1967). "Verification of computer simulation models," *Management Sciences*, ISSN 1816-6075, 14(2): pp. B-92-B101.
- Pala, Ö., Vennix, J.A.M., and Kleijnen, P.C. (1999). "Validation in soft OR, hard OR and system dynamics: A critical comparison and contribution to the debate," *Proceedings of the 17th international conference of the system dynamics society*, Wellington, NZ.
- Randers, J. (Ed.) (1980). *Elements of the System Dynamics Method*, ISBN 1-883823-44-7.
- Roberts, E.B. (1978). "Strategies for effective implementation of complex corporate models", In E.B. Roberts (Ed.), *Managerial Applications of System Dynamics*, ISBN 0915299593: pp. 77-85.
- Robinson, J.M. (1980). "Managerial sketches of the steps of modelling," In J. Randers (ed.) *Elements of the System Dynamics Method*, ISBN 1-883823-44-7: pp. 249-269.
- Rosenthal, R., and Rosnow, R.L. (1991). *Essentials of Behavioural Research Methods and Data Analysis*, (2nd Ed.), ISBN 0073531960.
- Russo, J.E. & Schoemaker, P.J.H. (1989). *Decision Traps*, ISBN 0385248350.
- Sargent, R.G. (2005). "Verification and validation of simulation models," *Proceedings of the 37th conference on winter simulation*, Orlando, FL.
- Shannon, R.E. (1975). *Systems Simulation: The Art and Science*, ISBN 0138818398.
- Sterman, J.D. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World*, ISBN 007238915X.
- Van der Zouwen, J. (1997). "The validation of sociocybernetic models," *Kybernetes*, ISSN 0368-492X, 26(6/7): pp. 848-856.
- Wakeland, W. and Hoarfrost, M. (2005). "The case for thoroughly testing complex system dynamics models," *Proceedings of the 22nd international conference of the system dynamics society*, Boston, MA.
- Zhu, H. et al., (1995). "Road Maps Glossary," Unpublished memo D-4498, Cambridge, MA: MIT.