

GUARANTEEING KNOWLEDGE CLAIMS

Mike Metcalfe

University of South Australia (City West)

Adelaide, SA 5000

mike.metcalfe@unisa.edu.au

Abstract

This paper will present a system for guaranteeing knowledge claims (research findings, conclusions) relevant to human design activities including research. It draws from the ideas developed by the systems thinker C. West Churchman (1914–2004), who wished to integrate individual experience, experimentation, alternative explanations and ethical considerations into a multi-element system to help designers and researchers reflect on knowledge claims. This paper will explore the conjecture that Churchman’s five element system provides a pragmatic for ‘guaranteeing’ design knowledge claims. The evidence to support this argument draw on some of the ideas Churchman presented in his book, ‘The Design of Inquiring Systems’, as well as the more generic argumentative inquiry, systems perspectives literature. A list of ‘guarantor’ questions for designer and researchers is provided as a summary.

Keywords: Churchman, guarantors, knowledge claims, human systems

GUARANTEEING KNOWLEDGE CLAIMS?

Introduction

There is only perspective seeing, only perspective "knowing"; the more effects we allow to speak about one thing, the more eyes, different eyes, we observe one thing, the more complete will our "concept" of this thing, our "objectivity," be. (from Nietzsche's Genealogy of Morals (Kaufmann, trans)

Those of us involved in research into the design of equitable 'technology-assisted' complex social systems require more than the methodologies of the physical sciences to guarantee¹ our findings, our knowledge claims. Claims of the form 'that system X is preferable to system Y' require subtle interpretations of complex social issues. For the non post modern designer and researcher, such interpretations need to be justified to a knowledgeable audience; argued ethically in preference to disputed alternatives. As Churchman (1971) put it, there is a requirement for some 'guarantors of truth'. While both the words 'guarantee' and 'truth' seem excessively 'objective' nowadays, they are useful to underline Churchman's approach to attempting to guarantee knowledge claims in the context of conflicting social tensions. The word 'truth' is being interpreted very liberally to include the objective 'one truth' as well as the interpretive approach of community-accepted knowledge claims. These are justified explanations of the world. This aligns with Churchman's broad definition of truth, so the two phrases 'guarantors of truth' and 'justified knowledge claims' would be seen as synonymous. Personal knowledge is being excluded.

This paper, therefore, agrees with Churchman that we need somehow to construct a system that attempts to guarantee knowledge claims about complex social choices, in order to be able to distinguish 'ignorance' or 'mistaken' opinion from '*Knowledge*'. A discipline is defined by its episteme. If designers determine that the scientific methods are sufficient to guarantee knowledge claims then it will be returning to engineering and dismissing the opportunity to include interpretive knowledge claims with its domain. If designers determine that knowledge can be personal, and not

¹ The terms 'guarantor', 'justification', 'warranted', and 'validated' are seen as fairly synonymous. The term 'guarantor' was used by Churchman.

be required to be guaranteed as far as possible to a wider audience then they will be aligning with some post-modernist, and perhaps putting lives at risk from new technologies. A middle road approach is to develop an agreed upon system of guarantee that is based in critical argument supported by reasoning and empirical evidence which allows all stakeholder groups to attempt to guarantee their interpretation of a situation.

There is an urgent need to make explicit an agreed upon system for guaranteeing the knowledge claims of designers and social activity researchers which will enable the identification of unsupported hunches from what is to be treated as a reasonable interpretation (i.e. knowledge claims) validated by reasoning and empirics, to the satisfaction of a knowledgeable community. We need to be able to distinguish the guaranteed from non guaranteed if design and social activity research is avoid very real dangers of institutionalised ignorance. Such ignorance allowed the horrors associated with the Nazi science of race, their persecution of “Jewish physics” and Stalin’s enforcement of “Marxist biology.” In both cases ‘ignorance’ could not be distinguished from guaranteed knowledge and as a consequence millions of people died. Writers are now calling for “Feminist algebra,” and “New Age Physics” (Stove, 1998). Some guaranteed middle ground between only recognising scientific, objective, or physical, knowledge and the ‘anything goes’ of post modernism may be appropriate for a discipline responsible for designing communities and their life-support and wealth-creating technologies. This concern for a system for guaranteeing knowledge claims about social activity designs needs to be adopted by consultants, text-book writers, lecturers, politicians, community leaders and social researchers. While somehow incorporating their years of experience, it needs to challenge them as to how these people know that what they are advising is ‘guaranteed knowledge’.

The aim, therefore, is to explore the conjecture that Churchman’s five element system for guaranteeing what we claim to know (including research findings) can be used as a pragmatic (works in practice). Extracting Churchman’s system elements from their context without over simplifying them is problematic, yet it is considered worth the risk as there is a real need to provide a pragmatic alternative to the dominant of the objective knowledge validation methods which are more relevant to the discovery activities of the physical science.

First, the paper will provide a brief look at Churchman's background to explain his assumptions about science, argument, systems and perspective seeking. This is followed by a more specific picking apart of some of his suggestions in, *The Design of Inquiring Systems*. What is picked out will of course be a personal interpretation of the author of this paper and a simplification of what Churchman seemed to wish to communicate in the rest of his book. Last in this paper, the implications of using his system will be briefly discussed.

Rational Justification, Systems and Perspective

Churchman's background as a philosopher of science, as a scientific engineer designing gun sights and as a writer on the mathematical techniques of operations research and mathematical programming, suggests he was anchored in the rationality of science. It is assumed he would have agreed with the famous quote from Hegel, 'that rationality is real' and with the suggestion that knowledge claims need to be argued before a sceptical audience. Reasoned argument and explanation are the basis of any guidelines to reflect upon how much guarantee can be afforded to a knowledge claim. Irrational ranting or un-argued belief is an unlikely source of guaranteed knowledge, although they may be the primary source of innovative conjectures that will later need to be rationally guaranteed. But, reasoning and empirics seem to be assumed to be insufficient by Churchman perhaps because many irrational acts have been well reasoned. Knowledge needs to be a community-available 'thing'; in Popper's terms, 'scientific knowledge' (1971). Personal knowledge, one person knowing something, is not 'knowledge'.

Churchman's constant use of the term dialectic argument seems suggest he was Socratic, he assumed that argument provided a realistic process of convincing a knowledgeable audience of any new piece of knowledge (research finding). The process of both creating knowledge and trying to guarantee that knowledge to others involved reasoned argument (debate, not quarrelling). The dialectic is creative, knowledge guaranteeing includes the presentation of conflicting evidence, alternative explanations and consideration of alternative perspectives (boundaries) to a sceptical audience. For more on argumentative inquiry see for example Crosswhite, (1996); Eemeren, et al., (2001); Perelman, and Olbrechts-Tyteca, (1969); Popper, (1963); and Habermas (1984).

As well as being scientific and an arguer, Churchman was a systems thinker. His interest in developing a system to guarantee social activity design knowledge claims seems to evolve with his thinking about the issue of the centrality of measurement as knowledge and the issue of universal boundaries, one perspectival science. As Ackoff (2000), Churchman's PhD student, constantly points out, the essential difference between systems thinking and scientific thinking is that of boundaries. In science there is one boundary for everything, our universe; within that universal truth. What is true in one place, generally speaking hopes to be true everywhere, over all time. System thinking uses the unit of analysis of a mentally imagined, interconnected, bounded, *system*. It may be a justice system, a payroll system, a defence system, a town, an organisation, a hen or a nation. It is bounded; changing that boundary changes the system perceived. For example, the production system becomes the organisational system by including the other organisational functions. Knowledge claims about a system do not have to be universal, only to be relative to the system under consideration. What is true for one system, one perspective and its occupants may not be for another.

Claims have to be agreed upon by all the elements of the system; stakeholders in a community. If the doctor element of a health system claims to have done a wonderful job of containing a contagious disease outbreak, this can only be 'guaranteed' knowledge if the finance, patient and drug supply elements of the hospital system agree. If there were insufficient notice from doctors for drug production rescheduling to fill the orders then the doctors have not done a wonderful job. Said differently, the systems perspective also addresses the generalisation requirement for guaranteed knowledge claims. To claim that 'John should not marry' is not as general as to claim, 'all men should not marry'. The greater the generalisability of a knowledge claim the greater the knowledge claim. Using systems thinking concepts, the generalisability needs to extend through the whole system under study but not necessarily all systems. The more 'universal' the system the more generalisable the knowledge claim.

Churchman (1971) sees the design of social activity as much more than the discovery activities of the physical sciences. These can only be interested in describing and explaining why (theory) physical events occur. Scientists are not able to be interested in re-designing the laws of nature. To design is to decide what is preferred; which of numerous alternatives is the one chosen? The

technology design literature (text books especially) is full of knowledge claims that design X is better than design Y. Is this design knowledge claim 'guaranteed' in any manner? This is not an issue for scientists as their methods of validating knowledge are insufficient for the design of human systems. Rather, design issues include those relevant to critical social theory (the Frankfurt School etc.) which aims to redesign social activity to emancipate the disadvantaged. Critical social theory has long claimed that social research needs to result in improved social action leading to emancipation. As will be discussed later, this seems to align with what Churchman means when he says that providing guarantees for knowledge claims needs to include hearing from all those involved in what is being designed, their interpretations somehow need to be included in any claim about how 'best' to re-design their activity.

Said differently, as is done in Hornsby's poem (1997), knowledge claims may be divided into three; objective, interpretive and critical, and can be viewed systemically. Rather than set these three against each other they need to be inter-related. The physical world is measured and tested using scientific, objective methods. So for example, when trying to first appreciate, and then design a response to, the complex social activity that delivered the Bali bomb attack, there will be some physical facts. When, where, and what? Rigour rules. Objects can be measured using the classic scientific research methods which are convincing because they can be repeated by the fiercest critic. When all agree on these measurements, perhaps of the number of deaths, explosion source and fire temperature, then a guaranteed knowledge claim can be by arguing about these physical aspects of the bombing. The measurements provide convincing evidence in support of the rational argument. The next fact to be assessed involves the interpretations. Why did they do it? Should they have done it? How could it have been done better? The scientific measurement methods based around the convincingness of repeatability are no longer of any use. Insights, ideas, and different perspectives are sought. How convincing will these be? Are they not just opinions? Guaranteeing knowledge still needs to use reasoned argument but now argument for alternative interpretation needs to be encouraged. Multiple insights need to be justified to a sceptical audience. The requirement of argument helps distinguish the 'insane' from the insightful. Moreover, these insights need to be guaranteed within the context of the human activity being studied.

Churchman's Five Guarantors

Looking now more closely at Churchman's book, *The Design of Inquiring Systems*, the title is problematic². He suggests an alternative, "The Design of an Inquiring Society", which hints at his grander intentions. But the introduction makes it clear he is exploring the extent to which research can be computerised, something very 1970s and something his Nobel Prize competitor Herbert Simon also focused upon. Churchman seems to be trying to identify how much we can computerise human inquiry design so as to distinguish what can and cannot be mechanised. He seems to be trying to bring out the issues, and thus improve our appreciation of human inquiry. His is a multiple perspective approach as opposed to Simon's earlier mono-decision tree approach. Churchman identifies three ways of seeing the world that need to be capable of being mastered by human inquiry skills. These are: 1) the world as composed of atoms (from Democritus), 2) the world as composed of purposeful entities (Aristotle) and 3) where events in the world are only known with a certain degree of probability (Carneades). It is the second one that seems most relevant to systems thinkers given the identification of the emergent property of purposeful action in human activity systems (see Ackoff (2000), Ulrich (1983) and Checkland (2000)). As Ulrich (2001), Metcalfe and Powell (1995), and many others have pointed out, purpose defines what is knowledge (relevant knowledge). Purpose causes problems to exist (a difference between what is sought and what exists) and inquiry is an attempt to solve that perceived problem. A tree does not 'know' anything, nor does it want to or need to know anything. Only a system with purpose can know things. A community with the purpose of defending itself from nature needs to 'know' many things.

There has been a rash of publications perhaps started by Courtney (1998) and summarised by Bennetts (2001) which have used *The Design of Inquiring Systems* to provide metaphors or stories for revealing different types of design or designers. These tend to play down the interaction between the five inquiry classifications. This paper takes a slightly different approach to Churchman's book; a much more epistemological one. It interprets the first section of the book as suggesting a five element system for attempting to guarantee design knowledge claims. That is, he designs an interdependent inquiry system of five fairly arbitrary elements for reflecting on how much guarantee can be afforded a knowledge claim. The design elements he gets from his own

² With thanks to Chris Stewart for alerting me to this.

background – the history of the theory of knowledge. One element he labels Leibnizian, who was one of the founders of calculus. Logic, and algebra provide a means of justifying knowledge. Its basis is repeatable thinking steps, logic; an in-the-head repeatability; a critical argument with yourself. This knowledge could be generated and validated by someone in a sensory-deprivation tank. It involves processing memory facts rather than sensory inputs. Given the mind's need to consider thoughts in a linear fashion, it is a completely mental process of associating a string of propositions using 'if-then' functions as in: If Socrates is a man, and all men are mortal, then Socrates is mortal. After some processing in this way, a whole series of facts can be thought of as connected by a sort of network of justified and related facts. Socrates is connected to mortality, Ancient Greece, public debate and so on. Ancient Greece is connected to Plato, the Iliad, and democracy and so on....

Practical application of this Leibnizian element of the system for attempting to guarantee knowledge claims can be demonstrated using the claim, "leadership is a communication role". The Leibnizian guarantor element may include logical/algebraic reasoning along the lines "if a group has 3 members, then there are 3 communication channels; if there are 5 people then there are 10 communication channels $[(n/2)(n-1)]$; there is an exponential growth. When a group has more than 10 people, more than 45 communication channels, then a different communication system is required. If all the communications are directed through one person, then there will only be 10 communication channels. This communication role is sometimes called leadership. This is a logical guarantor of the knowledge claim, but not sufficient.

The logical guarantee can only be as good as the quality of the reasoning that formed the connection links. So in the example, the reasoning for less than 45 communication channels may be questioned as to whether it works in practice. Russell, in the mid twentieth century, added another criticism than rather ended people's trust in the sole use of logic to guarantee claims. He demonstrated that many of the so called logical steps in most mathematical proofs were more steps of faith than pure reasoning. Perhaps logic alone, with its precise minute steps, was never really expected to be a vibrant source of innovative and creative knowledge claims or insightful interpretations useful for the design and validation of complex social activity. That said, logic is still considered one useful element in an overall system for attempting to guarantee knowledge claims.

Leaving aside the logical element, Churchman then discusses another guarantor element he names after the empiricist Locke. Guarantee may be through the senses, personal experience, including all sensory input (sight, touch, smell, and hearing); see for yourself, try it. This is 'out there' inquiry, outside the head. In the simple Lockean form, we wander about the planet absorbing experiences in the form of sense data which we store as personal knowledge. In this way, we continually expand what we think we know but as anyone who watches films knows, our senses are easily deceived. Both what we see and how we interpret what we see can deceive us. Experience becomes *unguaranteed* knowing, the more something appears to happen the more certain we become we have command of some knowledge when perhaps we are not testing it sufficiently. Guaranteeing knowledge includes wanting to convince others of what we think we know, and being able to do. This element of guaranteeing takes the form of saying, go ahead repeat my sensory experience for yourself, then you will experience what I did and be convinced I am correct. For example, if you wanted to convince someone that a speech contained mention of some issue then you could say to a sceptical audience, "listen for yourself, this is the original tape recording of her speech, what she actually said was..." The guarantee for the knowledge claim is through repeatable sense experiences. This tends to exclude spiritual knowledge claims.

Therefore, with the example of a knowledge claim that "leadership is a communication role" an empirical guarantee is required. This may take the form of a sociometric analysis where members of a group are asked who they talk to about work related issues. If everyone mentions one person, then the sociometric network will show this person as a central communications node; the hub. If this person had a 'leadership' title like, manager, then this would be empirical justification of the knowledge claim. This could be *repeated* for many different groups, and repeated by many different researchers. It could be falsified, and I suspect it would be due to our social habits of breaking up into 'family size' sub groups. Social networks tend to look like a series of loosely connected clusters. However, note that repeatable evidence, both in terms of logic and empirics, makes for very convincing guarantee.

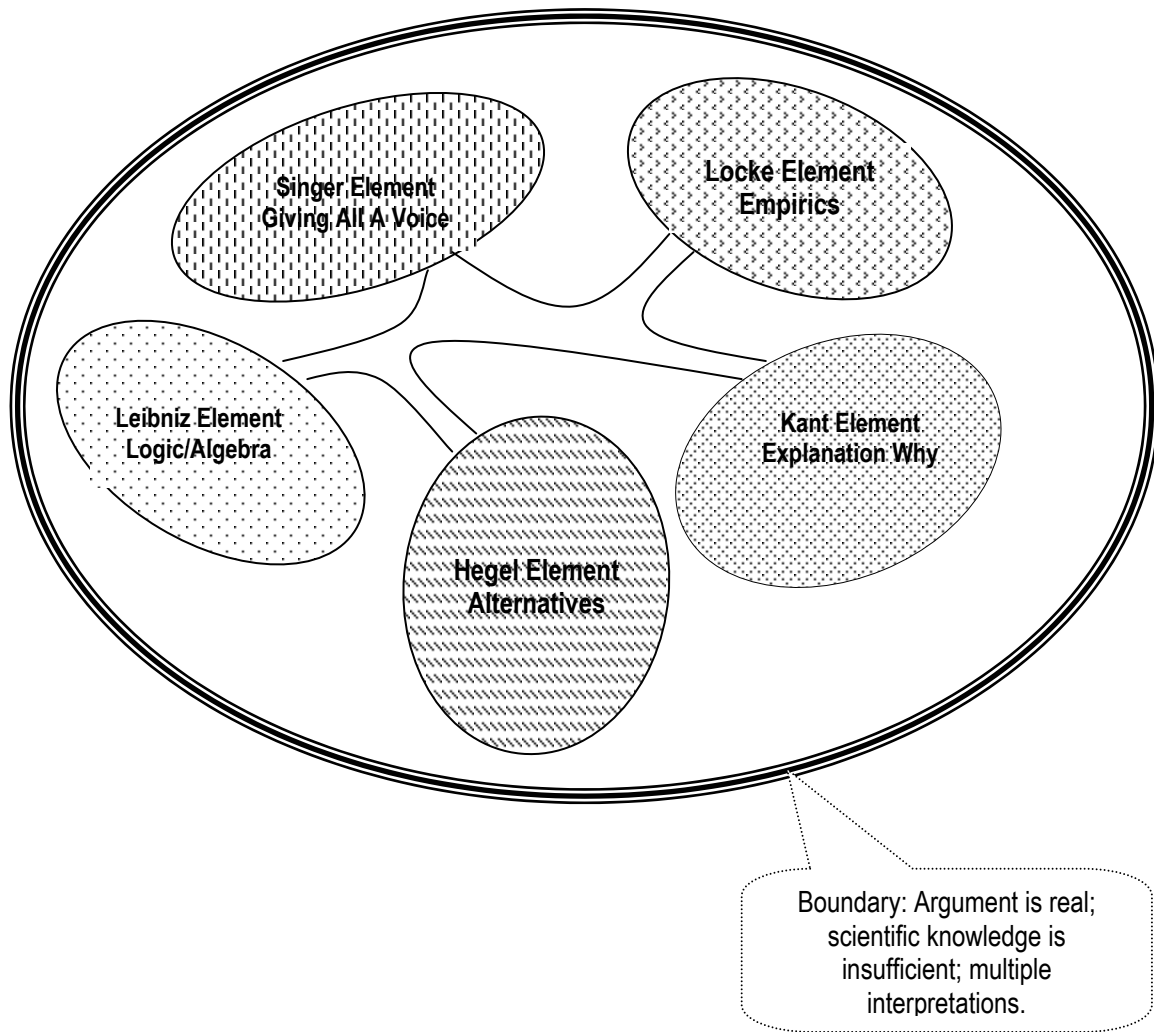
The use of empirics to provide some guarantee when it can, i.e. only with physical events, encourages an ever increasing demand for more accuracy of the sensory input; the precision of the observation. This leads to measurement and experiments which utilize careful observation under

Careful conditions. Convincing others of the accuracy of our empirical experiences becomes based upon the accuracy of recording the circumstances of our observations. Cohen (1994) argues that the unique quality of science is this rigor, the 'precision of empirics'. Given the ease with which people's senses can be deceived, sensory experiences collected under controlled experimental conditions provides preferable guarantor compared to everyday experiences. Thus the experimental scientist's knowledge claims are preferred over the experienced person. However, in many cases precision, repeatable, laboratory experiments are not possible, such as with the effectiveness of a military system in certain combat conditions. In these situations guarantee of knowledge claims is sought from the reasoning (logic) of the 'experienced' person but again this must be open to challenges. There is a large step from recounting what happened to explaining why it happened. In court 'eye witnesses' are allowed to repeat what they thought they saw. Only very credible 'expert' witnesses are allowed to interpret *why* something might have happened.

This begins to overlap with Churchman's next guarantor element, which is based on Kant's ideas on the need to combine explanation with empirics. Observations have to be *explained*. Theory, an explanation why, is sought. For example, *why* does a stick appear bent in water? One guarantee explanation (theory) is that light travels more slowly in denser mediums. But these explanations need to be logical, satisfactory to a knowledgeable sceptical audience. A guarantee needs to include an explanation of why the phenomenon is how it is. It is not sufficient to say, "Hey it works, see for yourself, I do not know why it works but it always does". A Guarantee that something works needs to include an explanation 'why'.

Therefore, the example claims that, 'leadership is a communication role' needs to be guaranteed by explaining 'why' leadership is a communication role? The logic/algebraic guarantor, while open to pragmatic criticisms (does it work in practice), is inherently explanatory. It explains that leadership needs to be a communication role because of the exponential growth of channels. The empirical guarantor is not so explanatory. If shown a socio-metric network with one central node, then the question, 'why' do people organise themselves like that, still needs to be asked and answered. Churchman's Kantian guarantee requires that *an* explanation be provided for these empirics. The intent is to encourage critical argument between explanations.

Figure 1: Churchman's Guarantee System



The next guarantee element (see figure 1) Churchman suggests for a knowledge claim about a socio-technical system he calls Hegelian. This guarantee starts a separation from the simplistic view of science, and moves towards a more Kuhnian view of science, that is, one of competing explanations. Explanations need to be made in the context of alternative explanations why, alternative theories. The argument is not 'that X is (or is not) proven' but that explanation X is preferable to explanation Y. The idea of seeking alternative explanations of the same phenomenon starts from Hegel's separation of the phenomenon under study from the perspective

being taken on that phenomenon. An example of the phenomenon may be a human activity such as national health policy. The different explanations for its failure may be seen as organisational, technical or personal as discussed by Linstone (1999).

For the 'leadership is communication' knowledge claim, alternative explanations may be that humans are a hierarchical and need to be led, that we break into family size sub groups to automatically counter the problems of too many channels, that the sociometric network merely reflects power through the control of resources, that in a complex world having one dominant worldview keeps things understandable, or that modern electronic communications mean the number communication channels can grow enormously. The original knowledge claim will be better appreciated if it explicitly competes with these sorts of alternative explanations. This paper provides another example. It is providing an alternative to how knowledge is guaranteed compared to other epistemologies such as the physical sciences, and post modernism.

The fifth guarantor element in the system for guaranteeing design knowledge claims Churchman calls Singerian after his mentor. This requires consideration of stakeholders' alternative interpretations of the designed activity. All possible rival perspectives need to be given a voice. This is an ethical imperative. Stakeholders' interpretations need to be 'swept in' and allowed for before knowledge claims that affect them can be guaranteed, if it is to be an ethical claim. At the start of this paper the example was given of doctors trying to claim they had done a wonderful job. If other parts of the hospital (e.g., drug suppliers) have a different interpretation that is not allowed for, then the doctor's claim cannot be considered ethically guaranteed. In the leadership example, this ethical guarantee may be achieved by ensuring a voice has been given to those with experience in leadership and follower roles, both good and bad. Group communication facilitators and those involved in group communications technology also needs to be given a voice.

So, the five elements and boundary, as depicted in figure 1 is believed to make up Churchman's system for guaranteeing knowledge claims. It can be described in systems terms. Each element alone in this guarantor system is insufficient; together there is self sustaining system which provides more optimism for guarantee. Each is sub-system in its own right allowing the epistemology of logic, algebra, empirics, theory development, contradiction and perspective to develop without upsetting

the overall guarantee system. As with organs in the human system, the elements are intended to interact. Voice needs to explain and be logical using empirics to counter alternatives. Empirics need to be logically explained. For some design or research activities certain elements are likely to be more dominant than others. A system has a purpose, a boundary. The purpose of this system is to determine if a knowledge claim can be guaranteed. The boundary around the system distinguishes it from objective science and from post modern relativism. Other guarantee systems are possible. It is not a 'critical' system in that it does not purposefully aim to produce a design or research that would satisfy the criteria of being empowering, however it does make some attempt to be ethical.

From System to Questioning Pragmatic

Churchman's five element system can be applied as a method of questions to any design or research findings. The questions below are only intended to be a guide, but they do attempt to include all the five elements and the boundary.

1. Boundary Guarantee

Has the research produced a knowledge claim? Has it produced something new, novel, or surprising to the majority of whoever is your knowledgeable audience? Is it falsifiable? Is it at least possible to find empirical evidence that counters the knowledge claim?

2. Logic/Algebraic Guarantee

Has the knowledge claim been justified to a knowledgeable audience using algebraic, logic, or mathematical reasoning, possibly in the form: 'if...then'? In the classic layout of a research article or thesis this may well be achievable as a result of using previous research and discussion (literature review) to reason for a knowledge claim. Alternatively it may suggest the use of logic in the form of a mind experiment: if X and Y then Z.

3. Empirical Guarantee

Can the knowledge claim be justified empirically? Is there any supporting evidence that can be seen, heard, smelt, touched or tasted? Can this experience be repeated by sceptical others? In situations where the experience cannot be repeated due to its context, e.g. the installation of the

first computer), can those recounting the experience (expert witnesses) provide reliable repeatable, precise 'eye witness' reports?

4. Explanation-Why Guarantee

Can you provide rational explanations to a knowledgeable audience as to *why* some phenomena are preferably explained using the knowledge claim rather than some other explanation? The justification for the knowledge claim needs to include more than "because it works in practice". Why does it work?

5. Countering Alternative Explanations-Why Guarantee

Does the evidence in support of the knowledge claim acknowledge and counter alternative explanations?

6. Ethical/Voice Guarantee

The justification of the knowledge claim needs to include consideration of all elements in the system; all stakeholders need to be given a voice; for their perspective to be justified.

7. Actioning the Knowledge Claim

As a result of justifying the knowledge claim what is recommended; so what? It is considered inadequate for social research to merely explain or describe, it needs to suggest a design for an improved world. Moreover, these actions should be actionable in every day decision making, i.e. they should not be too abstract.

In Summation

Churchman provides us with a system for uniting science with stakeholders' experiences with design. Guaranteeing knowledge claims about the design of human activity needs a different system than one adequate only for the physical sciences. Post modern definitions of personal knowledge and relativism may be a dangerous way to design communities and their technologies. Rather it is argued that design and research should result in a knowledge claim that comes with some guarantees. The elements of Churchman's system for providing such guarantees include:

- Being rigorously logical, algebraically stated were possible,
- Using empirics, repeatable empirics when available,
- Providing explanations why,
- Counter alternative explanations why, and
- Give all stakeholders a voice.

Hopefully, this will enable improved guarantee of design knowledge claims.

References

- Ackoff, R. (2000). Making a Difference, Systems Thinking/Systems Change, <http://www.judgelink.org/Presentations/GirlsLink/>.
- Bennetts, P. D. and T. Wood-Harper (2001). Churchman and Stories of Information Systems Development. Seventh Americas Conference on Information Systems, Boston.
- Checkland, P. (2000). "Soft Systems Methodology: A Thirty Year Retrospective." *Systems Research and Behavioural Science* 17(1): S11–S58.
- Churchman, C. W. (1971). *The Design of Inquiring Systems*. New York, John Wiley.
- Courtney, J. F., D. T. Croasdell, et al. (1998). "Inquiring Organizations." *Australian Journal of Information Systems* 6(1): 3–15.
- Crosswhite, J. (1996). *The Rhetoric of Reason*. Madison, University of Wisconsin Press.
- Eemeren, F. H., Ed. (2001). *Crucial Concepts in Argumentation Theory*, Amsterdam University Press.
- Habermas, J. (1984). *The Theory of Communicative Action: Reason and the Rationalisation of Society Vol.1*. Boston, Beacon Press.
- Hornsby, R. (1997). "Critical Thinking." *Systems Research and Behavioural Science* 14(4): 277–278.
- Linstone, H. A. (1999). *Decision Making for Technology Executives: Using Multiple Perspectives*. Boston, Artech House.
- Metcalfe, M. (1995). *Business Research Through Argument*. Boston, Kluwer Academic.
- Perelman, C. and L. Olbrechts-Tyteca (1969). *The New Rhetoric: A Treatise on Argumentation*. Notre Dame [Ind], University of Notre Dame.
- Popper, K. R. (1963). *Conjectures and Refutations: The Growth of Scientific Knowledge*. London, Routledge & Kegan Paul.
- Popper, K. R. (1971). *The Open Society and Its Enemies*. New Jersey, Princeton University Press.
- Stove, D. (1998). *Anything Goes*. New South Wales, Maclay Press.
- Ulrich, W. (1983). *Critical Heuristics of Social Planning: A New Approach to Practical Philosophy*. Chichester, John Wiley & Sons.
- Ulrich, W. (2001). "Critically Systemic Discourse: A Discursive Approach to Reflective Practice in ISD (Part 2)." *The Journal of Information Technology Theory and Application (JITTA)* 3(3): 85–106.