

Thinking Issues

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Research Paradigms and the Nature of Meaning and Truth

Computer science educators commonly have a strong background in mathematics, the physical sciences and the use of quantitative methods. This very education process, the perspective of computer science as a "scientific" discipline and the concomitant training to value rigour and objectivity in research, create a strong bias in beliefs about the "correct" way to undertake research, and the appropriate way to determine truth. The belief system may be evidenced in statements such as: "Oh I far prefer to deal with facts, rather than all that woolly stuff".

One means of classifying the computing disciplines is to think of them as "secondary" disciplines (in the case of computer science, with mathematics as a primary reference discipline). Or in the case of information systems as an integrative "tertiary" discipline including computer science, organisation theory, management, and sociology as some of the underlying reference disciplines. This distance from the core scientific discipline may often dictate the need for different approaches in research, and different techniques for knowledge confirmation. Thus computer scientists may need to apply different methods appropriate to computer science, while meeting the standard tests of rigour and validity of the physical science community. This gives rise to a certain tension for computer scientists which a colleague recently termed "physics envy".

But the purpose of this column is not to engage in the use of pejorative terms, but to discuss the differences in belief and approach in distinct research paradigms, and the limitations which arise from the application of each. This is especially important for those interested in computer science education research, since it is inherently transdisciplinary. It involves computer science as more akin to a physical science, and

education as a social science, which have very different assumptions and research approaches. Ironically while the natural science method highly values rigour, I have reviewed several submissions in the computer science education area, which are sloppy and superficial. Descriptive and anecdotal reports of a single technology and teaching innovation, with poorly framed goals, weak evaluation and non generalisable results, are not necessarily just poor research, but examples of inability to choose and use an appropriate educational research paradigm. In our National conference [1] we may accept such submissions, which I describe dismissively as "what I did in my holidays" articles, since we are trying to encourage practicing educators and novice researchers, but we would expect people to learn from their deficiencies and rapidly move on.

The distinction between the physical and social sciences can be described in terms of quantitative vs. qualitative paradigms. But research paradigms can be further thought of as comprising three distinct approaches [2], each based upon a distinctive worldview and perspective on the nature of knowledge. A convenient framework for categorising these three paradigms is offered by the German critical social philosopher Jurgen Habermas [3]. His three "knowledge interests" are depicted below:

Interest	Knowledge	Medium	Science
Technical	Instrumental (causal explanation)	Work	Empirical-analytic or natural sciences
Practical	Practical (understanding)	Language	Hermeneutic or 'interpretive' sciences
Emancipatory	Emancipatory (reflection)	Power	Critical sciences

Table 10 The knowledge constituted interests of Habermas [4]

As can be seen from the table above, each knowledge interest has a distinct set of assumptions and approaches to determining truth within its own confines.

This may be more simply explained by reference to the "X-Files" and the contrasting belief systems of Scully and Mulder. Scully the rational scientist - "the truth is out there"; Fox Mulder the enigmatic intuitive - "the truth is in here"; and further the X-files website, where one can buy X-Files caps and other commercial memorabilia - "the truth is neither here nor there"; truth is merely socially constructed. This mixture of science, of fiction, of entertainment and business combine as a form of truth. A truth designed to suspend the disbelief of captive viewers and earn profits for the film industry.

These constitute three distinct forms of truth - third person singular - "its truth", or objective truth as observed; first person singular, "my truth", or subjective truth as individually perceived; first person plural, "our truth" as socially constructed. For each of these belief systems a different research paradigm exists - the traditional or "classical" science objective paradigm, the social sciences interpretive paradigm, and the critical sciences evaluative paradigm.

Therefore if we are trying to assert a form of truth in our research, conscious selection of an appropriate paradigm is vital to the production of quality results. Thus, a formal experimental design may well be a sound method for determining the performance qualities of a new hardware architecture or network protocol. But for determining the efficacy of a new method of teaching programming for instance, I seriously doubt the value of formal experimental methods. Sample sizes are normally too small, the Hawthorne effect is all too prevalent, variables cannot be stabilised between iterations, ethical issues arise regarding the exclusion of one group of students from a new and potentially beneficial "treatment" or conversely their inclusion in a cohort of guinea pigs in an untried initiative. Typically a pragmatic amalgam of methods is adopted, with some acknowledgement that we are frequently engaging in interpretive field studies [7]. A combination of quantitative and qualitative evaluation is carried out. Triangulation of data from different sources, grades, effort estimates, costs, student perceptions, teacher perceptions etc. are used in concert to determine the efficacy of an innovation. Cf. [5], [7] for useful recommendations on effective evaluation. Longitudinal research and extended trials are normally required to

gain any degree of confidence in results.

One form of research well established in educational circles and considered highly appropriate for research into the improvement of teaching practice is Action Research [6]. There are several variants of action research itself, which align with each of our three paradigms, technical action research, practical action research and emancipatory action research [4]. In the latter method, practitioners align with the research community to jointly determine research goals, aimed at improving the conditions of the research community. This is not so much a "researching-of" a community in the traditional researcher as expert model, but a "researching-with" paradigm in which mutual expertises are acknowledged by all research participants.

Action Research in all its variants is a controversial research method in the computing field, with gradual acceptance and growing use in the Information Systems discipline and much less so in Computer Science. It has suffered from dual problems. Firstly it has been discredited from sloppy research design and reporting resulting in the "the what I did in my holidays" form of report of a personal activity. Secondly from its non-objective paradigmatic assumption. Action Research is a deliberately interventionist methodology aimed at bringing about an improvement in practice. For those steeped in the practices and beliefs of the classical sciences the difficulty of crossing paradigm chasms and determining how to achieve rigour in such an interventionist research method is a major barrier to its wider use. However, if the normal care in research design and evaluation is exercised this can be a very powerful method for effective computer science education research.

In conclusion, we need to be aware of the extent to which we are prisoners of our own worldview, and to adopt new and unfamiliar methods, which may be more appropriate to the research in question than the approaches we have traditionally used. When we are seeking to design and evaluate good computer science education research, the definition of rigour and the methodologies we adopt may differ from those to which we have traditionally been exposed.

1. Cf. National Association for Computing Qualifications (NACCQ) website: <http://www.naccq.ac.nz>
2. Orlikowski W., Baroudi J., (1991) Studying Information Technology in Organizations: Research Approaches and Assumptions, *Information Systems Research*, 2;1 pp. 1 - 26
3. Habermas J., (1972), *Knowledge and Human Interests, Theory and Practice, Communication and the Evolution of Society*, tr. J.J. Shapiro, Heinemann, London
4. Carr W., Kemmis S., (1983), *Becoming Critical: Knowing Through Action Research*, Deakin University Press, Victoria
5. Almstrum V., Dale N., Berglund A., Granger M., Currie Little J., Miller D., Peter M., Schragger P., Springsteel F., (1996), Evaluation Turning Technology from Toy to Tool: Report of the Working Group on Evaluation, ITiCSE Proceedings, June 2- 6 Barcelona: Retrieved Jan 29, 2001 from the World Wide Web <http://info.acm.org/pubs/citations/proceedings/cse/237466/p201-almstrum/>
6. Dick B., (2000), *Action Research Resources*. Southern Cross University. Retrieved January 24, 2001 from the World Wide Web: <http://www.scu.edu.au/schools/gcm/ar/arhome.html>
7. Klein, H.K., and Myers, M.D., (1999), A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems, *MIS Quarterly*, 23:1, pp. 67-93.