

Human-Computer Interaction Research: a Paradigm Clash?

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Abstract:

One of the major challenges in the emerging interdisciplinary field of human-computer interaction (HCI) is the specification of a research line that can enable the development of validated design relevant knowledge with a predictive power for the design of interactive systems. Based on the three different elements in the design of interactive systems: (1) human being(s), (2) technical artifact(s), and (3) context of use, different disciplines contribute with different research paradigms to this new field: social sciences with a strong empirical and experimental approach, and engineering disciplines with a strong technical and formal approach. This paper presents and discusses a possible way to integrate the strengths of different research and design paradigms.

Keywords: human computer interaction, science, design, engineering, paradigm

Introduction

All over the world, several research and development groups contribute to the growing area of human-computer interaction (HCI), based on the context in which each group is established (e.g., computing science, electrical engineering, psychology, etc.). The survival of these groups depends on their capabilities to adapt to their environment, and to which extent the whole community can be established as such. In this paper we try to

offer a broad view to continue a discussion about the possible scientific future of HCI. We will begin by describing some aspects of how scientific disciplines can evolve, which the relevant phases are, and what the possible requirements are that have to be fulfilled. In the next step we discuss the relevant paradigms and discuss how the different paradigms could be merged into a necessary new one.

Böhme, Van den Daele, Hohlfeld, Krohn and Schäfer [1] differentiate three phases of development in scientific disciplines: (1) *Explorative phase*: “Methods are predominantly inductive in character, and research is determined by strategies aimed at classification... The dynamics of the field are characterized more by discovery than explanation. The fine structure of the objects of study remains largely unknown, and is handled in a manner closely paralleling cybernetics’ famous ‘black box’. The scientist knows the relevant input and outputs – but what goes on between remains a mystery”. (2) *Paradigmatic phase*: “The onset of the paradigmatic phase is marked by the emergence of a theoretical approach which is able to organize the field. The introduction and elaboration of this approach represents a theoretical development with a definitive end. ... The theoretical dynamic of the paradigmatic phase is evidently one which can come to a conclusion – that is, can lead to mature theories which contain a fundamental, and in certain respects a conclusive, understanding of the discipline’s research object”. (3) *Post-paradigmatic phase*: “Where the organizing theories of scientific disciplines are clearly formulated and comprehensive, the possibilities of revolutionary changes or spectacular generalizations of their basic principles are commensurably reduced. Instead, the dynamics of theoretical development will be determined by the application of paradigmatic theories for the explanation of complex systems which can be subsumed within them” ([1], pp. 6-9).

It seems to be obvious that the actual state of affairs for the interdisciplinary field of HCI is in the *explorative phase* ([12], p. 45), maybe being able to move on to the paradigmatic phase in the near future. This statement does not necessarily exclude the possibility that different research communities contributing to HCI are already in a paradigmatic, or even in a post-paradigmatic phase. The main question so far is: how is it possible to improve the maturity of our discipline? To make an answer possible, we have to discuss the following issues: what is a paradigm, and what are the relevant paradigms for our scope of research?

Design paradigms

All over the world, a number of research disciplines (e.g., human-computer interaction, industrial design, engineering, etc.) are struggling with their ontological foundations, even if they are not fully aware of this. Following Kuhn's [9] model of scientific development, it can be proposed that the interdisciplinary and multidisciplinary research arena of HCI and USI may be considered an arena of several distinct 'communities' that coalesce around associated paradigms. 'Paradigm' is defined in the Kuhnian sense of a 'disciplinary matrix' that is composed of those (a) shared beliefs, (b) values, (c) models, and (d) exemplars that guide a 'community' of theorists and practitioners ([9], [10]). In his PhD thesis, Dorst [2] introduced and discussed the two most influential paradigms: (a) *positivism* for scientific research [13] and (b) *phenomenology* for design ([11]; see Figure 1).

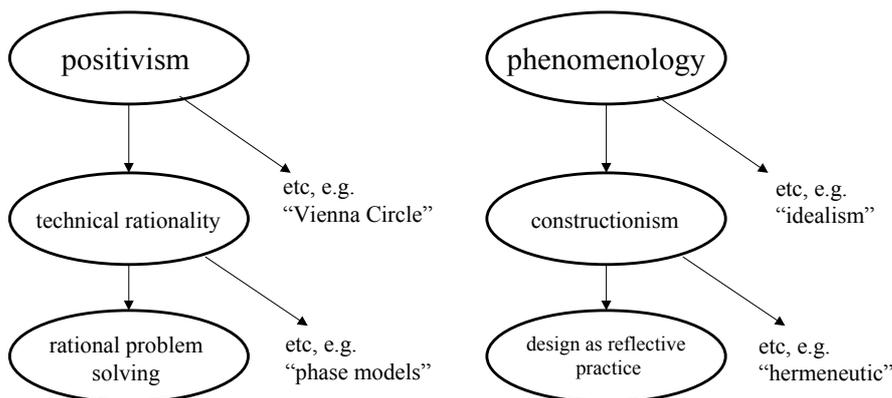


Figure 1: The two different paradigms, 'positivism' for research and 'phenomenology' for design.

Most of the dominant activities in natural and formal sciences can be characterized as a rational problem-solving approach under the 'positivistic paradigm'. This main approach can be described as ... "the search for a solution through a vast maze of possibilities (within the problem space)... Successful problem solving involves searching the maze selectively and reducing it to manageable solutions." [18]. In this paradigm, all knowledge should be described, represented and processed in an 'objective manner': independent of an individual and personal knowledge base (e.g. value system, beliefs). Opposite to this position, a personal knowledge base (e.g., 'craft skill') is exclusively accessible to the individual him/ herself, even sometimes without the opportunity for conscious reflection about the content (see also [19]). In natural

sciences most formal descriptions are – sooner or later – validated via empirical observations, experiments or simulation studies (e.g., Monte Carlo method, etc.).

But what can we say about design and engineering activities? To which paradigm do these activities belong? Dorst [2] characterizes these activities as ‘thrown’ into a design ‘situation’ (‘thrownness’ in German ‘Geworfenheit’, see [7]). Winograd and Flores [20] illustrate this kind of ‘thrownness’ as follows: “When chairing a meeting, you are in a situation that (I) you cannot avoid acting (doing nothing is also an action); (II) you cannot step back and reflect on your actions; (III) the effects of actions cannot be predicted; (IV) you do not have a stable representation of the situation; (V) every representation you have of the ‘situation’ is an interpretation; (VI) you cannot handle facts neutrally; you are creating the situation you are in” [20]. The following two main aspects characterize this kind of situation: (1) no opportunity for ‘reflection’ (see (I), (II), and (V)), and (2) no stable and [maybe] predictable reality (see (III), (IV), and (VI)). A design situation based on ‘thrownness’ is a typical context characterized by the latter two main aspects. The designer creates and synthesizes the situation while he/she is acting in. This is our primary motivation for replacing the term ‘phenomenology’ by the term ‘constructivistic’ paradigm from now on, to focus on the constructivistic and synthetic aspects of this paradigm.

Nowadays, the positivistic paradigm seems to be the ultimate characterization for a ‘scientific’ research line. But how can we incorporate ‘design’ as a scientific activity? The first aspect ‘no reflection’ could be overcome by approaches like ‘reflective practise’ as introduced by Schön [17]. Following Schön ([17], p. 129), a “practitioner approaches a practice problem as a unique case. He does not act as though he had no relevant prior experiences; on the contrary. But he attends to the peculiarities of the situation at hand.” The practitioner confronted with a concrete design problem “seeks to discover the particular features of his problematic situation, and from their gradual discovery, designs an intervention” or action ([17], p. 129). Schön’s concept of ‘reflection-in-action’ can be applied to a broad range of research activities, in which the scientist is looking for a particular solution for a given set of constraints (e.g., design of an experimental set-up, a formal proof, a research plan, a technical artifact, etc.; see also [15]). The implicit nature of all these activities is the synthetic approach, to come up with something concrete as part of reality (‘conrescence’, see Figure 2). The two

aspects of scientific activity ‘abstraction’ and ‘concrecence’ are both necessary and also complementary [6]. If this is an appropriate description, why then does science in the positivistic paradigm primarily focus on and praise their ‘abstraction’?

Given a reality at time t_1 , science in the positivistic paradigm observes and analyses particular phenomena in this reality, makes proper abstractions, and tries to predict similar phenomena for reality at time t_2 (see Figure 2). To preserve a stable reality [reality (t_1) = reality (t_2)], science in the positivistic paradigm has to operate under the following assumption, and this assumption seems to be essential: [$\{\text{model, theory}\} \notin \text{reality}$]. Whatever a theory about, e.g., the phenomenon ‘gravity’, explains and predicts, this theory does not influence or change the phenomenon ‘gravity’ at all. In this sense, models and theories of science in a positivistic paradigm are not part of the investigated and described reality; they are *apart* from this reality. We will use the term ‘reality’ further on to make this distinction clear compared to the broader meaning of the term reality.

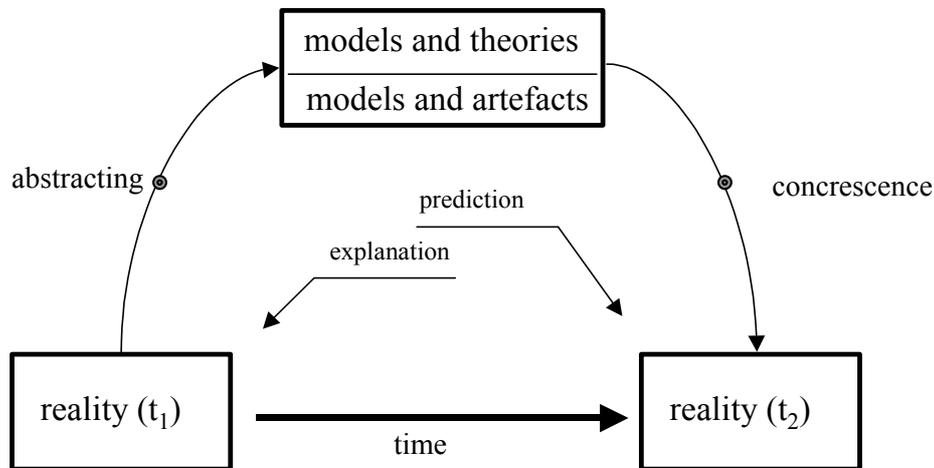


Figure 2: A general schema for the process of ‘scientific’ knowledge development.

The underlying mechanism to guarantee the fulfillment of the assumption is ‘reductionism via abstraction’. Any differences in empirical measurements between t_1 and t_2 are interpreted as just accidental factors (‘noise’), which do not contradict the theory. Only with knowledge, based on theories developed under the positivistic paradigm, the design of a concrete artifact is impossible, because the knowledge in these theories is purified from the changing contextual factors between reality at t_1 and

at t_2 . This lack of specific knowledge for any concrecence (e.g., ‘craft skills’) gives design and engineering disciplines their right to exist. Dreyfus [3] and Dreyfus and Dreyfus [4] stimulated a very important discussion about the importance of ‘intuitive expertise’, complementary to artificial ‘expert systems’ that ‘just’ follow rules.

Activities under the constructivistic paradigm claim to influence the reality and therefore to change this reality via the developed artifact [reality (t_1) \neq reality (t_2)], and in fact they do! The design and engineering disciplines develop knowledge to make the ‘concretisation’ successfully possible. This knowledge realized in the form of ‘model’ and ‘artifact’ can be interpreted as part of the reality, and not apart from it [$\{\text{model, artifact}\} \in \text{reality}$]. But how can design and engineering disciplines guarantee a ‘stable reality’? If models and artifact are seen as part of the reality, i.e., as a subset of the reality under consideration, then any action, which changes this subset, changes the whole set (reality) as well. So, engineering disciplines cannot guarantee a stable reality, and they do not want to [8].

Up to now, the main conclusion is that knowledge developed in the positivistic paradigm and knowledge developed in the constructivistic paradigm is different. If the schema in Figure 2 describes the whole process to develop knowledge, independent of a given paradigm, then the positivistic and the constructivistic knowledge can be seen as two subsets of a superset of knowledge: [$\{\text{model, theory}\} \cup \{\text{model, artifact}\} \equiv \{\text{model, theory, artifact}\}$]. In this sense we can describe them as *complementary* ([14]; see also the discussion of [5], pp. 212-214).

The most practical value of the ‘positivistic’ knowledge is the specification of limits and boundaries under which the ‘constructivistic’ knowledge has to operate (see left part “thesis” of Figure 3). For example, the actual state-of-the-art theory in thermodynamic explains and predicts that the design of a ‘perpetuum mobile’ is not feasible; therefore any attempt to design such a kind of system is unrealistic [6]. The challenge in combining both kinds of knowledge is creating an artifact (‘attractors’ as singularities, see middle part “antithesis” of Figure 3), which fall *inside* the constrained design space (see right part “synthesis” of Figure 3), provided by ‘positivistic’ knowledge. This kind of ‘validated design’ is quite challenging, because the designer has to take all relevant constraints and limits into account. This consequence usually is the main reason for designers to reject this position of being constrained by positivistic results. But still,

how can a scientifically sound *research* line be characterized that includes design-related activities?

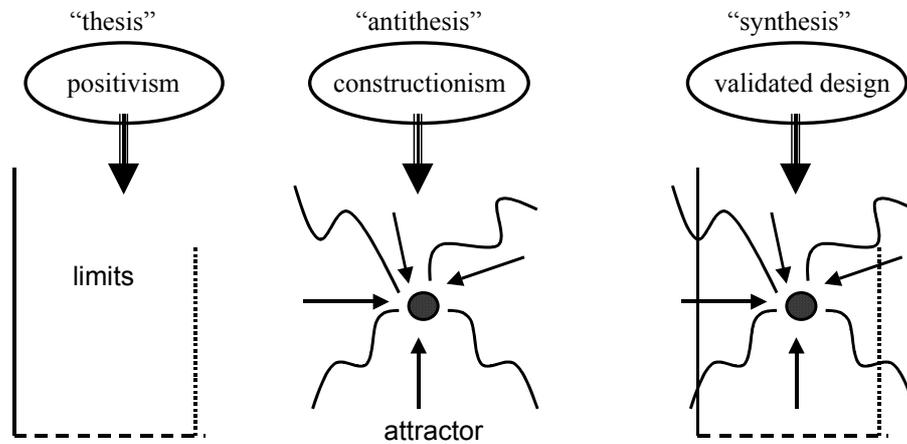


Figure 3: The two different kinds of design relevant knowledge provided by the positivistic ('thesis') and the constructivistic ('antithesis') paradigm, and the possible integration ('synthesis').

Conclusions

We will shortly describe and characterize the most well-established disciplines (following [16]). Disciplines such as physics, chemistry, etc. present themselves as 'natural sciences'. Theory development takes place in a strictly formal manner with a rigorous experimental validation practice. Truth is based on the conformity of empirical observations with the 'reality'. The most important basis for conclusions is 'inductive logic'. Scientific disciplines like mathematics present themselves as 'formal sciences'. Truth is based on logical consistency. The most important basis for conclusions is 'deductive logic'. On the other hand, humane disciplines can be classified as 'ideal sciences'. Truth is based on 'belief': hermeneutic evidence grounded in intuition! The most important basis for conclusions is a 'value system' based on an individual knowledge base.

How is it possible that sciences based on a positivistic paradigm claim and present themselves as 'true' scientific disciplines (compared to the rest), even if they include (and need) constructivistic and synthetic components as well? One possible explanation is the important asymmetry between both kinds of knowledge: 'positivistic' knowledge claims a more fundamental status than 'constructivistic' knowledge. 'Positivistic' knowledge has a stable predictive and explanatory power over time (see Figure 2; based

on the underlying idea of ‘absolute truth’), because it is particularly designed for this purpose. But this approach pays the price of not being able to reach reality: to explain and predict, but not to touch and change ‘reality’.

Acknowledgements

I would like to thank very much John Long for the intensive and fruitful discussions that improved this paper. I would like to thank Loe Feijs, Panos Markopoulos and Pieter-Jan Stappers for their valuable feedback and remarks on an earlier version of this paper.

References

1. Böhme, G., Daele, W. van den, Hohlfeld, R., Krohn, W. & Schäfer, W. (1983). Introduction. In: W. Schäfer (Ed.): *Finalization in Science: The Social Orientation of Scientific Progress*, 3-11. Dordrecht: Reidel.
2. Dorst, K. (1997). *Describing Design: A Comparison of Paradigms*. PhD thesis, Delft University of Technology, The Netherlands.
3. Dreyfus, H.L. (1992, 3rd ed.). *What Computers Still Can't Do: A Critique of Artificial Reason*. Cambridge: MIT Press.
4. Dreyfus, H.L. & Dreyfus, S.E. (1986). *Mind over Machine: The Power of Human Intuition and Expertise in the Era of the Computer*. New York: The Free Press.
5. Greif, S. (1991). The role of German work psychology in the design of artifacts. In: J.M. Carroll (Ed.): *Designing Interaction*, 203-226. Cambridge: Cambridge University Press.
6. Guillen, M. (1995). *Five Equations that Changed the World: The Power and Poetry of Mathematics*. New York: Hyperion.
7. Heidegger, M. (1927). *Sein und Zeit*. In: E. Husserl (Ed.): *Jahrbuch der Philosophie und phänomenologischen Forschung*, Volume VIII, [page numbers unknown]. Halle: Niemeyer.
8. Klemm, F. (1970). *A History of Western Technology*. Cambridge, MA: MIT Press.
9. Kuhn, T.S. (1962). *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.
10. Kuhn, T.S. (1974). Second thoughts on paradigms. In: F. Suppe (Ed.): *The Structure of Scientific Theories*, 459-482. Champaign: University of Illinois Press.
11. Merleau-Ponty, M. (1945). *Phénoménologie de la Perception*. Paris: Gallimard Press.
12. Myers, B.A. (1998). *A brief history of human-computer interaction technology*.

Interactions, 5(2), 44-54.

13. Popper, K.R. (1963). *Conjectures and Refutations*. London: Routledge.
14. Pylyshyn, Z. (1991). Some remarks on the theory-practice gap. In: J.M. Carroll (Ed.): *Designing Interaction*, 39-49. Cambridge: Cambridge University Press.
15. Reymen, I.M.M.J. (2001). *Improving Design Processes Through Structured Reflection: A Domain-Independent Approach*. PhD thesis, Eindhoven University of Technology, The Netherlands.
16. Sarris, V. (1990). *Methodologische Grundlagen der Experimentalpsychologie 1. Erkenntnisgewinnung und Methode*. München: Reinhardt.
17. Schön, D.A. (1983). *The Reflective Practitioner: How Professionals Think in Action*. New York: Basic Books.
18. Simon, H.A. (1969). *The Sciences of the Artificial*. Cambridge, MA: MIT Press.
19. Varela, F.J., Thompson, E. & Rosch, E. (1991). *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge, MA: MIT Press.
20. Winograd, T. & Flores, F. (1990). Understanding and being. In: T. Winograd and F. Flores (Eds.): *Understanding Computers and Cognition: A new Foundation for Design*, 27-37. Norwood, NJ: Ablex.