Interaction as an ecology — building a framework
Sharon Helmer Poggenpohl

While there has been considerable interest and discussion about the concept of interaction, it remains a slippery term begging for some structured understanding that can serve at least as a straw man or, even better, as a fundamental position from which to build a detailed understanding. What follows is a practical approach to thinking about such a framework from the perspective of design.

Searching for definitions
Often a discussion begins with a request for someone to define terms. The response is usually a 'here we go again,' groan, or pedantic smile. In this classic situation, everyone takes a step back as the context, meaning, and use of a term is presented — usually with a telling example. This is the situation with the term 'interaction.' There is no agreed upon definition and the term is even a subject of controversy.

A couple of years ago, in the process of trying to establish a meaningful vocabulary with which to tag design research, some doctoral students and I tried some experiments to form a social and (dare I say it?) interactive method for defining key terms. One of the experiments engaged five well-known international design professors to collectively (but anonymously) and iteratively define the term 'interaction.' This was not easy and the consensus we hoped would organically form had to be forced. The synthetic definition that formed after several rounds of discussion and amendment is:

> Interaction is a process of mutual or reciprocal influence among the variables or parts of a system. Interactions are a succession of actions, each responding to prior actions and each being responded to by succeeding action. By identifying and studying interaction patterns in this succession, we can design interventions that provide material support for desirable interaction patterns to emerge. The essential concept of interaction is reciprocal action, influence, or effect (Poggenpohl et al, in press).

The problem with one definition is that interaction is complex and may be more like a framework in which its various elements are fore-grounded or back-grounded or completely absent based on the context of use. But this framework doesn't exist even though aspects of it pop up in various attempts at definition. In light of this speculation and the existence of many definitions, I begin with a sampling of definitions from which tentative framework elements can be extracted.

But first — here is the controversy in a nutshell. In the process of questioning what is new about new media, Espen Arseth (2003, 418) answers that: "interactivity, hypertext, and virtuality offer partial, inconsistent, ideological answers to the question of newness…" He goes on to give a brief history of the use of the word 'interactive,' first in terms of the change from 'batch' modes of operating to 'interactive' modes, and then in terms of interactivity being 'better.' He suggests that interactive could be replaced with 'digital' in most texts and the meaning would not change; and he goes on to argue that

'interactivity' has no descriptive power. However, based on his analysis of various definitions, he places the definitions of interactivity into three categories:

1. a phenomenon involving the exchange of information between two equal partners, typically human; 2) a situation involving a feedback loop and response; and 3) composite definitions that talk of either degrees or components of interactivity. (425)

(Of the three terms he equates with newness, only virtuality survives his analysis.)

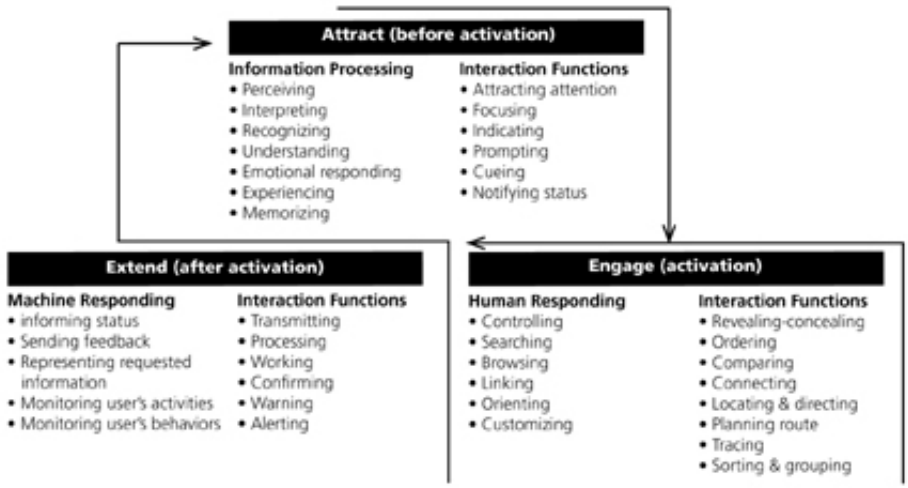
Separating the words 'interaction,' 'interactive,' and 'interactivity,' is the goal Dag Svanaes (undated, 5) sets himself. He arrives at the following distinctions:

> An *interaction* involves at least two participants. In the context of human-computer interaction, the human is *interacting* with the computer. I define an artifact to be *interactive* if it allows for interaction. I further use the term *interactivity* to denote the interactive aspects of an artifact.

While his conception is clearly stated, it has little explanatory power. The discussion goes on to focus on issues of representation in which the 'feel' of system use is an aspect of interactivity. Of particular interest is his discussion regarding shifts of human attention due to disturbances and breakdowns. This he likens to switching from the task-at-hand (writing this paper digitally, for example) to searching for an interface operation (how to get an ae ligature, for example). At a more sophisticated level, he uses the term 'ready-to-hand' (in use) as opposed to 'present-at-hand (dealing with the tool) after Heidegger's distinction (45-47). Identification of this sequentially fractured aspect of human attention strikes me as important.

The shift from objects to people is also a major issue. Another very focused attempt at disambiguating aspects of interaction in the context of human-computer interaction is the careful analysis provided by Jeamsinkul (2002). In the following diagram, what happens in less than the blink of an eye in terms of the shift from human to computer and back again is analyzed.

Figure 1 Jeamsinkul's close look at human-computer interaction



This analysis at a fairly fine level of conceptual granularity was constructed to support her work on the relation between motion affordance and its ability to complement software function in relation to common human understanding of motion meaning. Here interactivity is modeled based on a particular intent and within action theory's separation of communicative action initiated by people and instrumental action generated by object or machine.

Games are another specific domain in which interaction plays an essential role. Gunnar Liestøl's interest is 'gameplay,' but although he is suspicious of the term, he finds he cannot avoid interaction (2003, 402). In the same article, he references Brenda Laurel who describes interactivity in computer games based on three variables: "frequency (how often can one interact), range (how many choices are available), and signification (how much the choices really affect matters).

Taking games further, a new book (Salen and Zimmerman, 2004) quotes communication theorist Stephen Littlejohn who defines how interactivity emerges from a system: "Part and parcel of a system is the notion of 'relationship'….Interactional systems then, shall be two or more communicants in the process of, or at the level of defining the nature of their relationship." Salen and Zimmerman go on to say that "something is interactive when there is a reciprocal relationship of some kind between two elements in a system. Conversations, databases, games, and social relationships are all interactive in this sense. Furthermore, relationships between elements in a system are defined through interaction."(58) From their game-based analysis of interaction, these authors define four modes of interactivity:

> Mode 1: cognitive interactivity or interpretive participation (psychological, emotional, intellectual)
> Mode 2: functional interactivity or utilitarian participation (functional, structural interactions with material components)
> Mode 3: explicit interactivity or participation with design choices and procedures)
> Mode 4: beyond-the-object-interactivity or participation within the culture of the object (…co-construct communal realities…) (59-60)

Obviously the definitions cited here are not exhaustive, but they demonstrate the broad range of interest in interaction and some attempts at coming to grips with its meaning. These definitions range from very general to specific, locate themselves in specific contexts of use, and focus on different elements or themes within interaction. This reinforces the idea that a framework supports investigation more thoroughly than a definition and that a definition at this time may be premature.

Returning to the idea of interaction as a framework, what can be extracted from the above information? From the first, there is: reciprocal influence, parts of a system, successive actions. From Arseth, there is exchange of information, feedback loop and response. From Svanaes, the idea of shifting human attention (task versus operation). From Jemsinkul, there is a listing of sub-components of interaction (see figure 1). From Laurel, there are characteristics of interaction in terms of: frequency (time), range (scope), and

signification (effect/affect). From Salen and Zimmerman, there are modes of interactivity: cognitive/interpretive, functional/utilitarian, choice/procedure, and co-constructive/cultural.

What is suggested here is a method that uses the best ideas regarding interaction to construct a framework within which various researchers or practitioners might find their niche and the conceptual elements important to them. The construction of such a framework is beyond the scope of time and this paper, but it could contribute to establishing and understanding a discipline of interaction. Further, it would establish a context for identifying patterns of interaction.

Shifting from technology and systems to people and ecologies

One of the early and significant contributors to thinking about everyday people in the context of design was the sociologist Abraham Moles. His conception of micropsychology (1976) develops an accounting for human use based on micro-anxieties, micro-pleasures, micro-structures, micro-events, and micro-decisions. Surely interaction relates to this accounting from the standpoint of how well it supports or diminishes these qualitative aspects of use.

Moles describes the use of second-hand information.

> In a world which is the product of artifice, design more and more explicitly seeks to render the image of that world equivalent with the use project the individual may apply to it: It is in this equivalency that it finds the measure of its success. Wanting a legible world, design seeks to transform visibility into legibility, that is, into that operation of the mind that arranges things in the form of signs into an intelligible whole in order to prepare a strategy for action." (1986, 48)

Everyday people are seen by Moles to wander through an information environment created by design and now increasingly by technology with or without design. His concern is the generalized cost of wandering and the micro-anxieties this entails. Generalized cost concerns elapsed time, mental effort, stress of uncertainty, the success or failure of a micro-decision. These surely are subtle measures of interactive quality.

Following in his footsteps, Nardi and O'Day also take a people orientation in their critical book (1999). Societal and technological critics such as Neil Postman, Jacques Ellul, and Bruno Latour make appearances — this is not another hyberbole in the service of technology as a value-free and undeniably good enterprise. While much thought has been given to technological development; only recently has consideration of the human side of this system been given much consideration. Nardi and O'Day define 'information ecologies'as: "… a system of people, practices, values, and technologies in a particular local environment. In information ecologies, the spotlight is not on technology, but on human activities that are served by technology." (1999, 49) The connection between interaction and information ecologies is: "…examples of responsible, informed, engaged interactions among people and advanced information technologies. We think of the settings where we have seen these interactions as flourishing information ecologies."(24)

This provides an interesting context in which to develop an interaction framework as it sets the stage for a deeper look into the human side of interaction. Shifting from systems, a term that calls up rather dry, complex, technical, and contextually stable design, to ecologies that imply adaptation and co-evolution, seems like a better conception in the dynamic and changing situation in which we try to understand and map interaction.

Theorizing interaction from two perspectives: emotion and communication

After centuries of separation between mind and body in western philosophy, neuroscience is empirically discovering and theorizing the relationship of mind-body as a unity. Unfortunately the empirical discoveries are the result of studying people with brain injury, using various imaging technologies to reveal brain difference between normal and injured individuals. Enormous strides have been made in mapping brain structures and understanding its functional importance in terms of human emotion and behavior. One of the leading theorists in this area is Antonio Damasio, who postulates that emotion is aligned with the body and physiological changes, while feeling is aligned with the mind. He further states that emotion precedes feeling. He defends this position:

> It is legitimate to ask…why emotions precede feelings. My answer is simple: We have emotions first and feeling after because evolution came up with emotions first and feelings later. Emotions are built from simple reactions that easily promote the survival of an organism and thus could easily prevail in evolution. (2003, 30)

We tend to forget that we are animals who have passed through eons of successful evolution. Few of us fully appreciate the complexity of our physical reactions to stimuli, much less understand the underlying physiological and neurological systems. Damasio creates a hierarchy that puts physiological and more psychological constructs in order. From simple to increasingly complex, they are based on a nesting principle in which simple components at the bottom are folded into more elaborate ones higher up (see table 2).

Table 1 Damasio's nesting of regulatory reactions

Feelings according to Damasio are "thoughts with themes consonant with the emotion; and a mode of thinking, a style of mental processing, in which increases in the speed of image generation [neural mapping] make images more abundant." (2003, 84) This is with reference to good feeling; negative feeling has decreased image generation. One thinks here of Csikszentmihalyi's concept of 'flow.'(1990) Both would agree that people are drawn to harmonious action and seek pleasure rather than pain. Neural "[m]aps of a certain configuration are the basis for the mental state we call joy and its variants, something like a score composed in the key of pleasure." (Damasio, 137) And later, "Feelings are mental manifestations of balance and harmony, disharmony and discord. They do not refer to the harmony or discord of objects or events out in the world, necessarily, but rather to the harmony or discord deep within the flesh." (139) Damasio goes on to offer a provisional definition: "…a feeling is the perception of a certain state of the body along with the perception of a certain mode of thinking and of thought with certain themes." (86) And later he amplifies feelings as revelations about the state of a person and the mental events in a conscious mind that "…helps solve nonstandard problems involving creativity, judgment, and decision-making that require the display and manipulation of vast amounts of knowledge." (177)

Emotions and feelings color decision-making. Based on how we categorize the situations we experience — how we structure various scenarios and their importance in our life story — we get different options for action associated with different emotions and feelings. Of importance to this paper, is his conception of the 'emotionally competent object' as one that can initiate an emotion-feeling cycle. These can be actually experienced or recalled from memory. They remain at a high level of abstraction in his writing, but for designers the challenge is to more deeply understand what characterizes them.

Currently we are increasingly aware of cultural difference, but at a fundamental level we are all alike as human animals. It is important that we not forget this and Damasio's work is a keen reminder. It would be a mistake to focus solely on human cultural difference. A study mentioned briefly in the first part of this paper (Jeamsinkul, 2002), began from an embodied perspective to see if people interpreted basic motions on screen in a similar way and further studied whether they attached similar emotional characteristics to the motions. The results were impressive for some motions. This is the kind of empirical work that needs to guide interaction design; work in neuroscience will lead the way to such practical investigations.

Like neuroscience, communication theory is another area with a short history (Rogers, 1994). Because we live in communication, it was difficult to grasp and theorize; it developed after World War II with the work of Claude Shannon and Norbert Wiener, who created, respectively, the first diagram of message transmission (figure 2) and the concept of feedback and cybernetics (figure 3). Both were concerned with issues of technical transmission rather than the human dimension of communication.

Figure 2 Shannon's model of communication

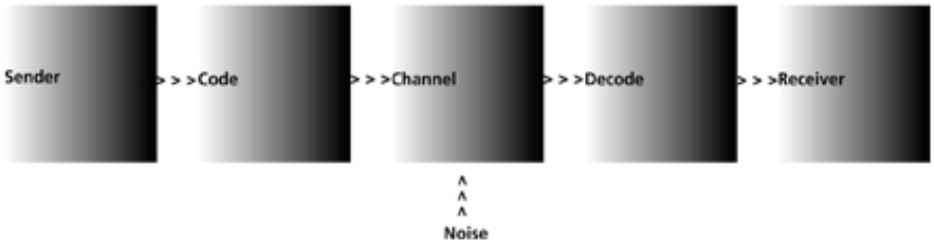
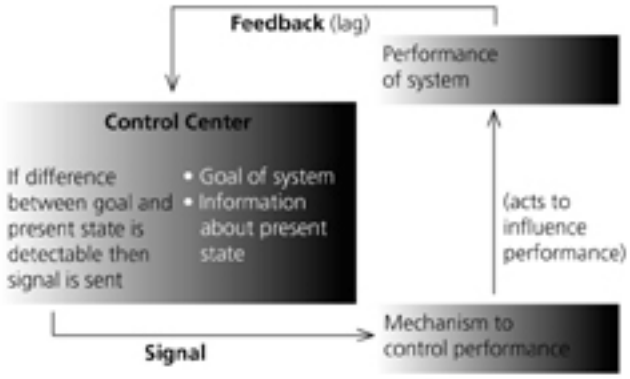


Figure 3 Wiener's model of feedback



Thus the early years of communication theory focused on technology and fidelity in broadcast media. Somewhat later, models emerged that focused on more human dimensions such as: discourse or the problem of establishing rapport; others attended to gratification or sustaining interest through expectation, motivation and emotional experience; yet others examined change (or innovation) through consideration of interpersonal influence, social norms, or persuasion; and finally some examined context closely to reveal media characteristics, everyday routines, feedback opportunities, assessment, etc. (For a detailed description of these models see McQuail & Windahl, 1993.) These models describe different contexts for communication much as I suspect interaction will reveal itself through multiple models.

Like interdisciplinary interest in interaction, communication models also span many disciplines from late 19th century philosophical and linguistic perspectives (Fernand de Saussurre and Charles Saunders Peirce) to perceptual psychological models in the 20th century (Wilhelm Wundt, Wolfgang Kohler and J.J. Gibson for example) to the already mentioned engineering and technological perspectives (Claude Shannon and Norbert Wiener). Behavioral perspectives came to the fore in the last half of the 20th century (Charles Osgood, Wilbur Schramm and a host of others). And now it is interdisciplinary perspectives from philosophy, linguistics, cognitive science, computer science, human-computer interaction, and design.

Much of the existing theory relates to mass communication in the context of broadcast or one-way media transmission. While

instruments that support interaction have been around for a long time (the telephone, for example), little if any theory focused on interaction itself. What is obvious is that turn taking is a phenomenon of interaction as is feedback and interpretation. Whether it occurs person-to-person or person-to-computer the situations are similar with the difference being the level of variability in the human context in contrast to the limited and programmed interaction in the person-to-computer context.

Three theorists offer concepts of use to thinking about interaction. The first of these is John MacKay, a contemporary of Herbert Simon. He envisions information as a kind of tool that operates on the recipient's 'state of conditional readiness for goal-directed behavior.' He identifies three kinds of meaning: 1) effective meaning to a recipient; 2) conventional meaning to a standard recipient; and 3) meaning that is inseparable from use. It is the last meaning that is of interest. (I will return to this momentarily.)

The second theorist is Charles Saunders Peirce (Parmentier, 1994) and the semiotic distinction between sign types: icon, index, and symbol. Icons are prevalent in computer application as they have an isomorphic relationship to what they represent. Symbols are abstractions that require learning both the form and the reference, thus they require more time and attention to process. Of these three, indices deliver actual connection (often dynamic) between the representation and the object or action of reference. For example, the movement of a horizontal band, filling in from left to right, that shows the progress of loading information is superior to the circle that rotates because the circle gives no span of time and marks no progress. The horizontal band is abstract and conventional, but it delivers more than just a sign of existence, it marks progress through time — it is dynamic feedback. This connects with MacKay's conception of meaning that is inseparable from use. I suspect that dynamic icons and indices, that reveal their state of being with reference to function or performance, will become more prevalent; further, that they will reveal meaning through use.

The third theorist is W. Barnett Pearce (1989), who examines communication through the lens of coordination, coherence, and mystery. While his concern is solely human communication and in particular forms of social, cultural, and political exchange, I believe this lens is useful to considerations of interaction. The conception of coordination leads to adjusting to the communication partner through attending to feedback, i.e., repairing misunderstood information, changing vocabulary or example, tuning in to the emotional/feeling state of one's partner and coming to some social exchange, understanding, or agreement that results in construction of a shared reality. Coherence leads to telling a consistent 'story' — often a story embedded in one's culture — or telling a story with clear or at least competent logic. Mystery leads to the infinite number of stories that can be expressed through changing perspective or interpretation; it is about the open-ended-ness of communication and the fallibility of the process of constructing reality. Investigation of interaction has primarily focused on coherence — creating logics, often from a computer science or design point of view rather than from

accommodating the user's perspective. Coordination is the dimension that acknowledges a partner who may have other interests or ideas; it is active and adaptive. Mystery relates to unfolding technological developments and experimentation that leads to new understanding with regard to how people use and understand them. Coordination, coherence and mystery work together, but these elements can be emphasized or downplayed in various ways. So far, computer-mediated communication has attended to technical and formal coherence rather than open the perspective to people and coordination.

These three theorists bring us different ideas in relation to interaction. The ideas themselves are at different levels of generality or specificity. MacKay delivers the idea of meaning in terms of demonstrable use; Peirce's indexical sign opens new territory for exploration in the area of dynamic display; and Pearce's coordination points to greater recognition and adaptation for the partnership aspect of interaction. From a communication perspective, we might ask why the creation of an interaction framework is important now. One answer is that communication and information permeate our lives and are a primary tool for learning.

Challenging the textbook

One example will have to suffice: learning with a textbook versus learning with an interactive program. First, a critical look at textbooks; they are a one-size-fits-all situation with little regard for different styles of learning, different levels of achievement, or different kinds of interests. Lev Vygotsky (1980) delivered a profound insight into the learning activity when he wrote about the 'zone of proximal development.' This zone is just beyond where the individual is knowledgeable, comfortable, and able to act; it provides a reasonable stretch or context for growth. Within the zone, frustration is minimized and harmonious feelings of success in mastering new knowledge are possible. The only adaptation to individual difference a textbook can provide is variable speed — reading quickly or slowly. The textbook is always a reading exercise with minor opportunities to support action beyond reading and writing. The textbook is fundamentally about acquiring and storing knowledge; it is not often about use of knowledge except in a secondhand way.

Looking past the medium of the textbook to the institutional system based on it, we find textbook adoption standardizes learning in subject areas across entire states in the United States with the largest states (California and Texas) influencing, if not dictating textbook adoption in entire regions of the country. This is institutional power. Another system outcome is the test — the regurgitation of information previously assimilated, but not necessarily put into a context of use as the measure of achievement. Escaping the lock that textbooks have on learning is a formidable challenge.

If we look at textbooks from Pearce's three dimensions of communication, we find very strong coherence in the story telling, limited coordination on an individual level, but strong coordination on an educational system level, and next to no mystery. Attempts to break the tradition of the textbook meet high resistance in part

because those controlling education have been educated in the textbook tradition. It is difficult to step aside from the often hidden visual and pedagogical forms that the textbook presents. Bolter and Grusin's discussion of 'remediation' (1999) reminds us of the hold previous structures and visualizations have on us. Today one only needs to look at CNN or other news channels to see the 'windows' concept migrating from computer to television screen. In a similar way, computer-based learning is often a remediation of textbook characteristics.

From a speculative standpoint, interactive computer-based learning opportunities should be able to redress the limitations of the textbook by going beyond static text and picture and traditions of show and tell to more discovery-based learning constructed on interactive choice, experimentation, or trial and (yes) error. It should be able to support the social construction of learning, which of course requires interaction. Such learning may present alternative entry points to understanding ideas. For example to understand the concept of co-evolution one might explore the relationship between the Dodo bird and the Calvaria tree, or the dynamics of mice population and acorn production. One's interests, level of knowledge, and learning style can be accommodated, opening learning to a more tailored process that respects individual zones of proximal development. This glimpse of possible change in the learning environment is a revolution equal to the mechanical production of books and the pedagogy that developed. Understanding interaction is an important component of this revolution.

Ending and beginning

This paper has suggested the need for an interaction framework rather than a general definition; it has demonstrated that telling elements and theories that might help construct such a framework can be identified. Beyond identification is a process of synthesis (Owen, 2001) in which elements are clustered based on similarity or difference. Development of an interaction framework will necessarily cross disciplines, experiences, and contexts and require the thinking and collaboration of many individuals. An interaction framework is possible, but it will not be conclusive. It needs to be responsive to new knowledge and revisited periodically to provide an up-to-date reference for those interested in newer, more relevant approaches to communication, knowledge acquisition and dissemination, and human work.

Resources

Arseth, Espen. 2003. We All Want to Change the World: The Ideology of Innovation in Digital Media. In Liestøl, Gunnar, Morrison, Andrew and Rasmussen, Terje. 2003. Digital Media Revisited, Theoretical and conceptual innovations in digital domains. Cambridge: MIT Press.

Bolter, Jay and Gursin, Richard. 1999. Remediation, Understanding New Media. Cambridge: MIT Press.

Csikszentmihalyi, Mihaly. 1990. Flow, the Psychology of Optimal Experience. New York: Harper & Row.

Damasio, Antonio. 2003. Looking for Spinoza, Joy, sorrow, and the feeling brain. New York: Harcourt.

Jeamsinkul, Chujit. 2002. Methodology for Uncovering Motion Affordance in Interactive Media. Ph.D. dissertation, Illinois Institute of Technology.

Jeamsinkul, Chujit and Poggenpohl, Sharon. 2002. Methodology for Uncovering Motion Affordance in Interactive Media. Visible Language, 36.3, 254-280.

Liestøl, Gunnar. 2003. "Gameplay": From synthesis to analysis (and vice versa). In Liestøl, Gunnar, Morrison, Andrew and Rasmussen, Terje. 2003. Digital Media Revisited, Theoretical and conceptual innovations in digital domains. Cambridge: MIT Press.

MacKay, Donald. 1969. Information, Mechanism, and Meaning. Cambridge: MIT Press.

McQuail, Denis and Windahl, Sven. 1993. Communication Models. New York: Longman.

Moles, Abraham. 1976. Micropsycholgie de la Vie Quotidienné. Paris: Denoël Gonthier.

Moles, Abraham. 1986. The Legibility of the World: A Project of Graphic Design. Design Issues, Vol 3 No 1, 43-53.

Nardi, Bonnie and O'Day, Vicki. 1999. Information Ecologies, Using technology with heart. Cambridge: MIT Press.

Owen, Charles. 2001. Structured Planning and Design: Information-age Tools for Product Development. Design Issues, Vol 17 No 1, 27-43.

Parmentier, Richard. 1994. Signs in Society, Studies in Semiotic Anthropology. Bloomington, IN: Indiana University Press.

Pearce, W. Barnett. 1989. Communication and the Human Condition. Carbondale, IL: Southern Illinois University Press.

Poggenpohl, Sharon, Chayutsahkij, Praima and Jeamsinkul, Chujit. 2004. Language definition and its role in developing a design discourse. Design Studies, in press.

Rogers, Everett. 1994. A History of Communication Study. New York: The Free Press.

Salen, Katie and Zimmerman, Eric. 2004. Rules of Play, Game design fundamentals. Cambridge: MIT Press.

Svanaes, Dag. Undated. Understanding Interactivity, Steps to a phenomenology of human-computer interaction. Online document www.idi.ntnu.no~dags/interactivity.pdf

Vygotsky, Lev. 1980. Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.

[30,335]