Communication Design and Theories of Learning

Brad Mehlenbacher
Adult & Higher Education
North Carolina State University
Raleigh, NC 27695-7801
1.919.515.6242
brad_m@unity.ncsu.edu

ABSTRACT

This paper provides a brief overview of the ill-structured information spaces that communication designers create and inhabit, highlighting the need for a research-based understanding of learning. A sociocognitive approach to learning that benefits from the strengths of cognitive and social perspectives is described. As a complex learning activity, communication design and use demand creative, multidisciplinary approaches to data collection, analysis, and interpretation.

Categories and Subject Descriptors

H. [**Information Systems**], H.1. [**Models and Principles**], H.1.0. [**General**].

General Terms

Design, Documentation, Human Factors, Learning Theory.

Keywords

Cognitive, Communication, Design, Learning, Social, Theory.

In a world in which the total of human knowledge is doubling about every ten years, our security can rest only on our ability to learn [11, p. 34].

... what the student, or at least the student who thinks, knows is that further study is required [47, p. 30].

1. 21ST CENTURY PROBLEM SPACES

As communication designers, we produce information and information spaces that explain, describe, elaborate on, guide, instruct, support, and complete the technologies that others use. That information demands their attention and interaction as readily as natural and cultural information for, as Borgmann [10] notes,

> … [technological information] introduces a new kind of information. To information *about* and *for* reality it adds *information as reality*. The paradigms of report and recipe are succeeded by the paradigm of the recording. The technological information on a compact disc is so detailed and controlled that it addresses us virtually *as* reality. What comes from a recording of a Bach cantata on a CD is not a report about the cantata nor a recipe — the score — for performing the cantata, it is in the common understanding of music itself. Information through the power of technology steps forward as a rival of reality [p. 2].

As a rival of reality, the information spaces that we design and engage in present themselves to us as ill-structured problem domains. Ill-structured domains, according to Spiro, Feltovich, Jacobson, and Coulson [51], exhibit the following characteristics: "(a) each case or example of knowledge application typically involves the simultaneous interactive involvement of multiple, wide-application conceptual structures (multiple schemas, perspectives, organizational principles, and so on), each of which is individually complex (ie., the domain involves concept- and case-complexity); and (b) the pattern of conceptual incidence and interaction varies substantially across cases nominally of the same type (ie., the domain involves across-case irregularity)" [p. 60].

In short, ill-structured domains are unstable and demand flexibility, a creative ability to organize across single data points and to understand, argue, and evaluate categorically, that is, at the conceptual level. Moreover, ill-structured domains require strategies for carrying what has been learned into new situations and contexts, for managing trade-offs, and for turning that understanding into actions [29].

Within this context, communication designers and users can be characterized as symbol-making, symbol-using problem solvers, attempting to discover — through varying combinations of trial, error, and selectivity — accurate state and process descriptions of some element of nature [44]. Problem-solving individuals must, in turn, create and maintain "intensional networks" where, according to Nardi, Whittaker, and Schwarz [43], "Joint activity is accomplished by the assembling of sets of individuals derived from overlapping constellations of personal networks." On top of that, the relationship between individuals and their environment involves an ongoing interaction between (a) incoming information about the status of the environment (perception), (b) information processing (thinking), and (c) environmental response(s) (motor activity) [54, p. 10]. Since these individuals' problem spaces are ill-structured ones, they must constantly and creatively contend with complex and changing problems, goals, sub-goals, and with their current knowledge of the solution constraints and the bounded nature of human rationality [50, 56].

Communication designers and users are therefore frequently engaged in ill-structured domains, collecting, sorting, analyzing, interpreting, designing, and reporting data, and collaborating, communicating, interacting, and negotiating with other problem-solvers. And none of these activities offer single solution paths or obvious checkmate situations [34, 52]. They are what Chi,

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Glaser, and Rees [18] call "real world problems" and, as such, present "… new obstacles that were not encountered previously in puzzle-like problems" since "the exact operators to be used are usually not given, the goal state is sometimes not well defined" and "a large knowledge space" is essential [p. 7]. For Jonassen [33], ill-structured problem solving requires that learners enact seven complex processes:

1. Articulate problem space and contextual constraints
2. Identify and clarify alternative opinions, positions, and perspectives of stakeholders
3. Generate possible problem solutions
4. Assess the viability of alternative solutions by constructing arguments and articulating personal beliefs
5. Monitor the problem space and solution options
6. Implement and monitor the solution, and
7. Adapt the solution [pp. 79-83].

Although problem solving and ill-structured problem domains have received attention in the instructional and communication design research [e.g., 17, 25], researchers have spent less time describing communication designers and their audiences as *learners* first and foremost, who engage in complex *learning* activities whenever they interact with information. This paper provides a brief overview of current research on learning for communication design researchers and practitioners.

2.COGNITIVE LEARNING

Learning has been systematically studied by cognitive psychologists for several decades [1, 12, 20, 39, 45, 50]. A cognitive information-processing model of learning involves the following critical information-human interactions:

- **Information + Comprehension** (attention, selection, working memory, cognitive workload)
- **Representation + Integration with existing and available knowledge** structures (encoding, strategies for potential storage in long-term memory, information mapping, schemata, and interaction with external resources)
- **Retrieval + Development of new connections** between the new information and the existing state of understanding (reviewing, associative reasoning, mental models, conceptual organization, and interaction with external resources), and
- **Construction + Elaboration toward a richer understanding** of the subject matter, leading to expert understanding and/or behaviors (practice, reorganization of material for problem setting, plan and goal development, propagation, and situational exigencies).

Notably, these information-human interactions should not be interpreted as representing "levels" of understanding such as comprehension, application, analysis, synthesis, and evaluation [cf., 8, identify, describe, analyse, theorize hierarchy, p. 67]. In models such as Biggs [8] and Bloom's [9] *Taxonomy of educational objectives* (produced by an American Educational Research Association-sponsored committee chaired by Bloom), the problem is that "understanding" becomes, in Bereiter's [6] words, "the ghost in the taxonomy" [p. 94]. That is, clearly knowledge exists prior to the first level, comprehension, and all other levels represent alternative *uses* of that knowledge. To sidestep this problem, the focus needs to be on information rather than on knowledge, achieved by including external resources as part of the repertoire of learners, and incorporating situational exigencies into the interaction that learners engage in while establishing how what they are learning will be applied and in what context.

Hede and Hede [30], addressing learning that involves simultaneous interaction with multimodal media elements, stress learner attention as critical to the learning process. Learners' problem-solving approaches, combined with motivation, cognitive engagement, intelligence, and reflection, influence how learners attend and control visual input (textual, graphical, video, and animated) and auditory input (narration, instructions, cues, and music). Learner attention and time spent on the learning task are fundamental to the learning process. As the amount of input increases, learners must compensate by increasing the amount of cognitive information processing (ie., working memory) applied to the learning situation (see Figure 1):

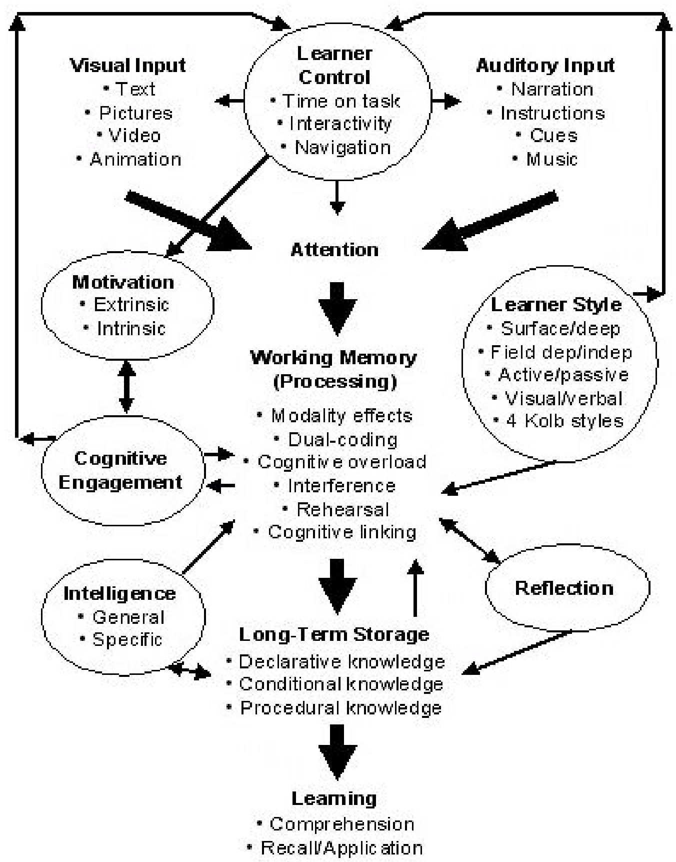

Figure 1: Integrated model of multimedia effects on learning (adapted from [30])

The initial goal, then, is to find ways to facilitate multi-level learning, that is, learning that involves a combination of factual and conceptual knowledge, the ability to apply that knowledge, and feedback on learner progress. Connecting this goal to understandable learning tasks and activities, designing learning environments that encourage discussion and on-task behaviors and, in doing so, drawing on technologies and artifacts that support these efforts follows naturally from the initial goal. As the number of tasks, the need for navigation, and the types of interactivity unrelated to the primary learning objectives and goals increases, the amount of learning necessarily decreases. Ultimately, shifting learning to doing, learners are able to focus less on strategies for searching and more on identifying information patterns, production detection and automatic action, and on the nuances of their context: these abilities distinguish the experienced from the inexperienced [12].

Both experienced and inexperienced learners develop rich mental models of learning tasks and concepts, sometimes used synonymously with prototypes and schemata, that guide them as they apply knowledge to a given situation and acquire new knowledge for use in new situations [32]. Winn [59] distinguishes between mental models and schemata, suggesting that the former "… is broader in conception than a schema because it specifies causal actions among objects that take place within it" [p. 90]. Critical to the formation and development of mental models is the process of selective perception, wherein learners actively emphasize or deemphasize information depending on prior knowledge and information familiarity. As well, given the integral role of selection in the problem formation process, some researchers argue that the selection process is critical to creativity and innovation in learning [22, 48].

Selective perception is also a process that minimizes cognitive workload (which is always, hopelessly limited), particularly as tasks grow in complexity (ie., are longer in duration, require higher accuracy, and demand more working memory) and learners develop their expertise in a given domain (through prior experience and similar interpretive outcomes). Feinberg, Murphy, and Duda [28] further elaborate on the importance of cognitive load learning theory which involves sensory memory, working memory, and long-term memory, distinguishing between *intrinsic* cognitive load (instructional content) and *extrinsic* cognitive load ("… any cognitive activity engaged in because of the way the task is organized or presented, not because it is essential to attaining relevant goals") [p. 107]). Quellmalz and Kozma [46] describe intrinsic cognitive load as being optimized by working *with* technology and extrinsic cognitive load as being an effect *of* technology:

> What complicates how we measure cognitive load is the various different causes that contribute to its level, some of them supportive of learning and some detrimental. If our attention is split between two different information types or if modality types demand either auditory or visual processing, cognitive load is increased. And both of these demand types are intensely connected to the nature of the instructional content, how much or little redundancy is represented in the information, and on other design features of the instruction.
>
> Effects *of* technology are those residual changes in students' cognitive capacity that result from the use of technology to learn. Effects *with* technology are those performances that students display while equipped with a cognitive tool, such as a visualiser, analysis package, or a model builder. From the latter perspective, some cognition is performed by the person and some by the technology that they use…. [p. 291].

The prior knowledge or mental models that learners bring to any information, therefore, can be critical to providing them with strategies and heuristics for managing the processing event. Johnson-Laird [32] views mental models as integral to human meaning-making, writing

> … mental models play a central and unifying role in representing objects, states of affairs, sequences of events, the way the world is, and the social and psychological actions of daily life. They enable individuals to make inferences and predictions, to understand phenomena, to decide what action to take and to control its execution, and above all to experience events by proxy; they allow language to be used to create representations comparable to those deriving from direct acquaintance with the world; and they relate words to the world by way of conception and perception [p. 397].

Other concepts integral to an information-processing model of learning include the limited capacity assumption [16], dual-coding or -channelling [40], cognitive workload [41, 53], mental representation and modeling [32], and cognitive flexibility [51, 52], and these processes all focus on the learner's ability to manage incoming information in real-time. Berninger and Richards [7] remind us that a learner's "… functional systems involve many different components that have to be orchestrated and thus the complexity of the learning process" [p. 317] and, so, even at the comprehension stage of the learning process, humans are actively engaged in acquiring incoming information (auditory, visual, or textual) and in selecting, interpreting, and sorting in microseconds the resulting information for possible storage in long-term memory. Dietz [24] describes human activities as involving individual abilities (e.g., selecting, interpreting, etc.), coordination activities (communicating with others), and production activities (acting with others), and this simple division of learning foci enables us to begin conceptualizing a more integrated picture of learning that incorporates cognitive and social views of learning.

Carmean and Haefner [15] are attempting to provide an integrated view of "multi-level learning" when they elaborate on "deeper learning principles" that inform all learning environment designs. Their "students" and "faculty" are replaced by learners and instructors to highlight the general usefulness of their principles for learning. Importantly, their deeper learning principles combine cognitive operations (e.g., knowledge retrieval, trial and error, reflection) and social factors (e.g., cooperation, activities situated in action) (see Table 1):

Table 1: Deeper learning principles (adapted from Carmean & Haefner, 2002; citing Bransford, Brown, Cocking, & National Research Council, 2000; Brown, 1992; Chickering & Erhmann, 1998; Marchese, 1998, 2002; Merrill, 2002)

Learning is	When …
Social	It involves cognitive apprenticeship. It prompts reciprocity and cooperation among learners. It offers prompt feedback. It encourages contact between learners and instructors. It emphasizes rich, timely feedback.
Active	It is engaged in solving real-world problems. It is intertwined in judgment and exploration. It is situated in action. It uses active learning techniques. Practice and reinforcement are emphasized. Involvement in real-world tasks is emphasized.
Contextual	New knowledge builds on the learner's existing knowledge. New knowledge is integrated into the learner's world. Knowledge is applied by the learner. New knowledge is demonstrated to the learner. Learners have a deep foundation of factual knowledge. There is awareness that learners come to the classroom with preconceptions about how the world works. Learners understand facts and ideas in the context of a conceptual framework. Learning is concrete rather than abstract.
Engaging	It respects diverse talents and ways of learning. It communicates high expectations. It is done in high-challenge, low-threat environments. It emphasizes intrinsic motivators and natural curiosities.
Learner-owned	Learners organize knowledge in ways that facilitate retrieval and application. Learners take control of their own learning: noting failures, planning ahead, apportioning time and memory to tasks. It emphasizes time on task. It emphasizes learner independence and choice. It allows time for reflection. It emphasizes higher-order thinking (synthesis and reflection).

3.SOCIAL LEARNING

Engeström [26] agrees that a broader definition of learning incorporating social dynamics, situated cognition, and human activity theory is required, describing individual models of learning as following an "enlightenment view of learning." What is missing in such views of learning is an emphasis on dialectics, discourse use, and on instructor-learner transformation. An enlightenment view of learning, Engeström [26] argues, maintains that

> Learning is a fairly simple matter of acquiring, accepting, and putting together deeper, more valid facts about the world. Of course, this tacitly presupposes that there are teachers around who already know the facts and the needed course of development. Inner contradictions, self-movement, and agency from below are all but excluded. It is a paternalistic conception of learning that assumes a fixed, Olympian point of view high above, where truth is plain to see [p. 530].

The picture of learning that Engeström [26] is taking issue with here is a natural outcome of the transmissional model of instruction and communication, a model that represents learning as an entity or object rather than as an event or process. Engeström's [26] description of learning naturally accounts for instructional activities, learner motivation and engagement, social interaction, and complex learning environments. Likewise, existing views of learning informed by deterministic notions of technology present information as stand-alone and modular rather than as a developed and developing part of the learning process. Attending to the interaction between learning and technology thus enriches our understanding of our basic learning processes. As Krendl and Warren [35] note, "The focus on individuals' attitudes toward, and perceptions of, various media has begun to introduce a multidimensional understanding of learning in relation to media experiences. Multiple factors influence the learning process — mode of delivery, content, context of reception, as well as individual characteristics such as perceived self-efficacy and cognitive abilities" [p. 69].

4.SOCIOCOGNITIVE LEARNING

Many discussions of learning unfortunately emphasize the polar ends of the landscape between purely cognitive and social, the one position stressing information-processing models and the other, constructivist ones. Indeed, one cannot talk about or read research on learning that does not draw contrasts between cognitive or information-processing views of learning and social or constructivist ones. The historical tension between cognitive and social perspectives on learning has never been greater than during the last several decades. Cognitivists argue that social constructivists have tended to over-situate learning and, in doing so, have become advocates of theories of learning that are nonpragmatic and difficult to evaluate. Social constructivists maintain that knowledge cannot be removed or decontextualized from application or context and that cognitivists are behavioralists who liken cognition to limited computer-processing models.

Certainly cognitivists owe a great deal to historical behavioralist traditions [e.g., 1, 2]. And certainly behavioralism serves as the great and convenient strawman of the modern psychological tradition, to hear social constructivists frame historical developments in the field. This of course further heightens the tensions between the two groups.

Cognitivists have accused social constructivists of wresting knowledge away from the individual learner entirely, leaving them with only specific learning circumstances and non-generalizable contexts for learning. Barab and Plucker [4], indeed, have squarely set cognitivism under "traditional" learning theories and maintain that "Educators … have fallen victim to a circular logic: Traditional, entity-based theories, placed knowledge in the head of the learner, which led to the creation of educational systems that focused on transmitting content into individual minds" [p. 165]. Lave [37], too, asserts that "Common theories of learning begin and end with individuals (though these days they often nod at 'the social' or 'the environment' in between)" [p. 149]. Contrary to this assertion, however, Simon [49] does more than nod to context when he writes, "The proper study of mankind has been said to be man. But I have argued that man — at least the intellective component of man — may be relatively simple, [but] that most of the complexity of his behavior may be drawn from man's environment…." [p. 159].

Most behavioralists and cognitivists would generally agree that effective learning occurs when the instructional content, medium, setting, and desired learning outcome are similar in composition. Additionally, similar to behavioralists, cognitivists continue to stress the importance of thoughtful sequencing of conceptual and procedural content in well-designed steps [14, p. 13]. Social theorists, influenced by Vygotsky [57], stress that all learning involves a complex interaction between individuals, artifacts, and societal elements in a purposeful and communal process. Notably, a Vygotskian perspective [57] also values the relationship between novices and experts, a research focus shared by many cognitivists [18, 50].

Both perspectives on learning, though, share the belief that the transmission of knowledge is a two-way process and that instructor-communicators need to acknowledge and respond to the constructed nature of all learning. As Benbunan-Fich, Hiltz, and Harasim [5] remind us, "… knowledge has to be discovered, constructed, practiced, and validated by each learner" [p. 21] and, in order to accomplish this, each learner must interact with a community of learners, in effect, to test through trial and error various developing versions of the "knowledge within the head of the learner." Importantly, Benbunan-Fich, et al. [5] stress that constructivist theories of learning should not be confused with the "Pedagogical methods [that use] this approach, including collaborative learning, creat[ing] learning situations that enable learners to engage in active exploration and/or social collaboration, such as laboratories, field studies, simulations, and case studies with group discussion" [p. 21]. These instructional activities emphasize having learners actively *do* something as part of their learning experience, and research supports the benefit of learning-by-doing [12].

As well, cognitivists and social constructivists are sometimes misrepresented as only focusing on individual learning versus environmental, social, or group learning. Instead, as Anderson, Greeno, Reder, and Simon [3] stress, "The cognitive approach should not be read as denying the value of learning in group activity, and the situative approach should not be read as denying the value of learning by individuals working by themselves. The difference between the perspectives involves different ways of focusing on learning activity, but both perspectives provide accounts of learning that can occur in groups and in solitary activity" [p. 11].

In reviewing the research and practical influence of emerging technologies on instruction and learning, whether framed cognitively or situationally, it is often useful to focus first on how individuals learn and then to broaden one's object of inquiry to include artifacts, other learners, and other environmental or contextual variables [58]. To this end, Newell and Simon [44] admit taking a pragmatic approach to the development of information-processing theory:

> It is difficult to test theories of dynamic, history-dependent systems. The saturation with content — with diverse meaningful symbolic structures — only makes matters worse. There is not even a well-behaved Euclidean space of numerical measurements in which to plot and compare human behavior with theory. Thus, this book makes very little use of the standard statistical apparatus [p. 13].

Contrary to the criticisms of cognitive perspectives towards psychology, Newell and Simon's [44] description of the interplay between general models of cognition and context anticipates recent developments in the field. As Winn [59] summarizes

> There is evidence that cognitive activity is not separate from the context in which it occurs…. Thinking, learning, and acting are embedded in an environment to which we are tightly and dynamically coupled and which has a profound influence on what we think and do. What is more, evidence from the study of how we use language … and our bodies … suggests that cognitive activity extends beyond our brains to the rest of our bodies, not just to the environment [p. 80].

Evans [27] echoes this position as well, stating "The world we perceive to be out there is as much a product of cognition in a human body as it is the result of an external reality…. Hence, our world-view as human beings is exactly that, a view from one possible ecologically viable perspective among many possible perspectives" [p. 8]. Davies [23] agrees, as least where our perception of time is concerned, noting "We must face up to the fact that, at least in the case of humans, the subject experiencing subjective time is not a perfect, structureless observer, but a complex, multilayered, multifaceted psyche. Different levels of our consciousness may experience time in quite different ways" [p. 266]. Vosniadou [55] too argues for this perspective in a much less speculative manner, recommending that "What is needed is to change our conception of the mind from that of a symbol manipulating machine to that of a developing, biological system that functions and evolves within a complex physical, social, and cultural environment" [p. 2]. Her [55] conclusion rests, interestingly, on the initial success of cognitive science research where, she writes "… the turn to instructional interventions and experiments as a means of doing basic science happened precisely *because the epistemology of cognitive psychology could not provide an adequate learning theory to explain the results that it had itself produced* [pp. 100-101].

Anderson, et al. [3], situating studies of cognition and learning in formal educational settings, take a much more collaborative position:

> The cognitive and situative perspectives also provide valuable complementary analyses of school learning. For example, in mathematics education the cognitive perspective provides important analyses of information structures in conceptual understanding and procedures that are needed for students to succeed in the tasks emphasized in most mathematics curricula…. The situative perspective provides important analyses that emphasize students' participation in socially organized activities of learning, including patterns of classroom discourse and the opportunities to learn how to participate in the learning practices that their classrooms support…. A more complete cognitive theory will include more specific explanations of differences between learning environments, considered as effects of different contexts, and a more complete situative theory will include more specific explanations of individual students' proficiencies and understandings, considered as their participation in interactions with each other and with material and socially constructed conceptual systems [p. 12].

It can be argued then that demanding adherence to either a cognitive or a social perspective towards learning is unnecessary and counterproductive. These perspectives might, instead, emphasize a particular dimension of a larger sociohistorical or even anthropological methodological stance towards the study of human psychology in general [21]. Ultimately, conceptions of the study of learning might draw on various quantitative and qualitative methodological traditions, casting alternative views of the same activities or processes. Table 2 provides a coarse outline of how different approaches to learning could invite different emphases and methods of engagement:

Table 2: Alternative views of the same activities or processes

Approach	**Emphasis**	**Specific Methods**
Biophysical	Physical, motor, neurological	Electronencephalography (EEG), ERPs, fMRI, MEG, NIRS, PET, TCDS
Behavioral	Behavior, perception, tasks	Direct observation, trial and error, punishment-reward, time-stamping
Cognition	Cognition, mind as computer	Attention, selection, retrieval, mental models, schema, cognitive overload
Organizational	Tasks in context	Activity theory, genre analysis, social network analysis
Social	Human interaction	Situativity theory, discourse analysis, critical realism, political theory
Cultural	Community, social conventions	Anthropological approaches to situativity and community formation, structural and poststructural analysis
Historical	History, events	Economic, sociological, narrative, critical theory

Beginning one's investigation with a sociocognitive orientation provides opportunities for framing instructional and communication information spaces as both profoundly personal and individual and intensely sociocultural in nature. Barab and Plucker [4] find that the literatures on legitimate peripheral participation, distributed cognition, activity theory, and situated cognition offer promising developments in this direction, writing, "… talent [knowledgeable skillfulness] is not in the head or in the environment, but in the variables of the 'flow itself'" [p. 178]. Hutchins [31] as well concludes that "… most learning in … setting happens in the doing, the changes to internal media that permit them to be coordinated with external media happen in the same process that bring the media into coordination with one another" [pp. 373-374]. This perspective certainly finds support in recent research on mindful learning which, according to Langer [36] stresses perspective rather than the assimilation of context-free facts: "When we ignore perspective, we tend to confuse the stability of our mind-sets with the stability of the underlying phenomenon: All the while things are changing and at any one moment they are different from different perspectives, yet we hold them still in our minds as if they were constant" [p. 221].

5.CONCLUSIONS

The information spaces that communication designers build, inhabit, work and learn within are becoming increasingly sophisticated for both designers and users. Purely task-oriented perspectives towards communication designers or information users de-emphasize the complex of learning issues that come into play when individuals interact with information and communication technologies.

Surprisingly, the interaction between researchers studying communication design and researchers studying instructional design and learning theory is limited. This lack of interaction may be less a factor of the interstitial nature of the products and processes they study than it is of their oddly separate historical research traditions (humanities versus educational). Practitioners, however, are motivated to understand and influence particular processes and products, so they have a right to be frustrated by the lack of productive exchange. Developing richer understandings of learning that draw on research describing both cognitive and social perspectives towards learning provides communication design researchers and practitioners with a shared understanding of the complex nature of learning.

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